Insects

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 74.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME FACTORS IN THE NATURAL CONTROL OF THE MEXICAN COTTON BOLL WEEVIL.

BY

W. E. HINDS, Ph. D.,
In Charge of Cotton Boll Weevil Laboratory.

Issued December 14, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

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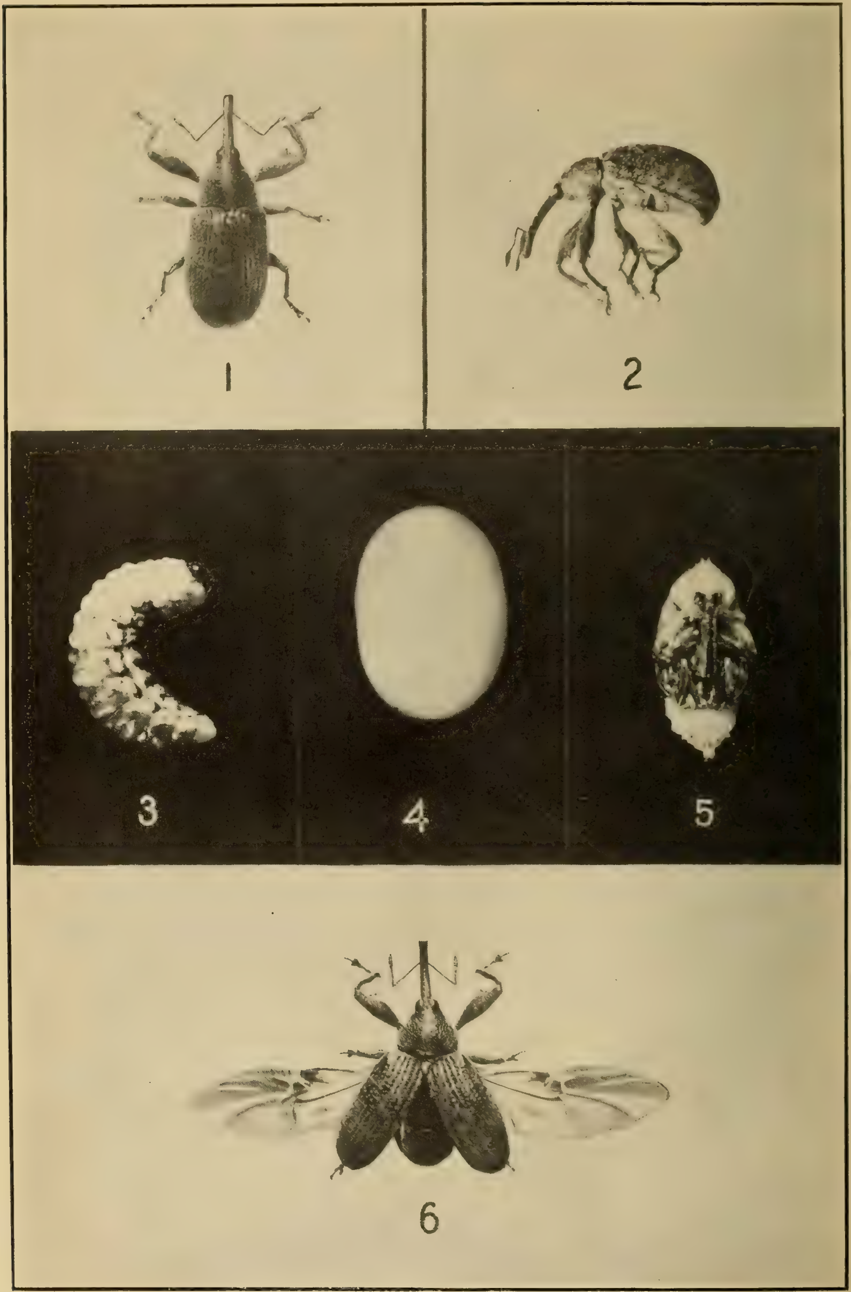

STAGES OF MEXICAN COTTON BOLL WEEVIL.

Fig. 1.—Adult weevil, dorsal view. Fig. 2.—Adult weevil, side view. Fig. 3.—Full grown larva, side view. Fig. 4.—Egg. Fig. 5.—Pupa, ventral view. Fig. 6.—Adult with wings spread. All except fig. 3 enlarged to 4 diameters; fig. 3 enlarged to 35 diameters. (Original.)

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Mabel Colcord, *librarian.*

Cotton Boll Weevil Investigations.

W. D. Hunter, *in charge.*

F. C. Bishopp, R. A. Cushman, Springer Goes, W. E. Hinds, C. E. Hood, C. R. Jones, Wilmon Newell, W. D. Pierce, F. C. Pratt, C. E. Sanborn, C. S. Spooner, W. W. Yothers, *special field agents.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., August 20, 1907.

Sir: I have the honor to transmit herewith the manuscript of a paper, by Dr. W. E. Hinds of this Bureau, entitled "Some Factors in the Natural Control of the Mexican Cotton Boll Weevil." It deals especially with three important factors of natural control, concerning which our knowledge has been largely extended through the cotton boll weevil investigations of the Bureau during the season of 1906. These factors are: Temperature and moisture conditions, predaceous and parasitic enemies, and food supply.

In view of the fact that the boll weevil is not a passing pest, but rather an enemy with which the cotton grower must reckon each year, it is evident that our knowledge of every factor affecting favorably or unfavorably its development and attack must be made as complete as possible. While it may not be possible to increase the effectiveness of some of these factors, there is reason to believe that with our more exact knowledge of the nature of their effect upon the weevil and of the conditions under which they produce most beneficial results others may be utilized far more than has been done heretofore, thus lessening very materially the damage annually inflicted by the weevil at little, if any, expense.

This study of the natural control of the boll weevil is probably based upon one of the most extensive series of definite examinations and records which has ever been made in economic entomology. The paper reporting this work is therefore based upon a large amount of statistical data. This has been tabulated with a view to as much condensation as possible without destroying the value and significance of the records. The illustrations accompanying the manuscript are necessary for the best understanding of the text. I recommend the publication of this report as Bulletin No. 74 of the Bureau of Entomology.

Respectfully,

F. H. Chittenden,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

In the earlier work of the cotton boll weevil investigation particular attention was given to the life history and habits of the boll weevil and the direct effect of these upon cotton production.

These phases of the investigation have been described in a number of circulars and bulletins of the Bureau of Entomology, among which the reader is referred especially to Bulletins 45 and 51, by Hunter and Hinds, and Bulletin 63, Part I, by Prof. E. D. Sanderson. The present bulletin deals especially with three factors of natural control in regard to which our knowledge has been largely extended by the work done during the season of 1906.

Those who are engaged in the cotton boll weevil investigations of the Bureau of Entomology are frequently asked if the boll weevil is not a passing pest, which may be expected in time to leave the cotton fields where it now occurs, because of a continuation of the onward movement by which it has spread through the great area which it now infests. This idea is doubtless based upon the fact that in any locality, in a series of seasons, there is likely to occur one season in which there will be a marked decrease in the abundance of the weevils. As a consequence of this an unusually good crop may be made, and after such a season with little weevil injury the planter is naturally inclined to anticipate that the weevil may never again become as serious a pest as it has been in the past.

The continuation of this investigation through a number of years has made it possible to determine that local variation, such as has been referred to, may be due directly to the influence of certain natural factors which, either singly or in combination, have exercised an unusually large degree of control upon the weevil. It has been possible to determine the most important factors concerned in this control and in some measure to show their relative importance. Extensive observations, however, have but confirmed the impression, which was formed years ago by entomologists engaged in studying this question, that the boll weevil is not a passing pest, but rather an enemy which must be taken into account every year by the grower of cotton throughout the infested area. With the certainty that the fight against the weevil must be continued indefinitely, it has become increasingly evident that our knowledge of every factor affecting, favorably or unfavorably, the development and attack of the boll weevil must be made as complete as is possible. While it may be impossible to increase the influence or effectiveness of some of these factors, there is excellent promise that it may be possible to utilize others to a far greater degree than has been done in the past, because of our more exact knowledge of the nature of their effect upon the weevil and of the conditions under which they produce most beneficial results. It is possible that by this greater utilization of natural forces the damage annually done by the weevil may be very materially decreased at little, if any, expense.

By ''natural control'' is meant the combined effect upon the weevil of all natural enemies and of all conditions or forces in nature which retard or prevent the development of the weevils and reduce the injury which they might otherwise inflict upon the crop. These are, in general, the factors which operate to produce and to preserve what is often spoken of as ''the balance in nature.'' The principal factors are temperature and moisture conditions in summer and in winter, the attack of predaceous enemies or parasites, and the dependence of the species upon a favorable condition of food supply.

Since the beginning of the present cotton boll weevil investigations in 1901, the work in the field has been continuously under the direction of Mr. W. D. Hunter, to whom is due credit for many of the suggestions followed and for the breadth of scope which it has been possible to give to this particular portion of the investigation. Under his direction the work has been planned and carried out under the immediate supervision of the writer. Nearly all of the special field agents who have been in the investigation have had some part in the collection of material or in the examinations involved in securing the data for this bulletin. Special acknowledgment is due to them for the large amount of painstaking work without which this study could not have been made sufficiently extensive to have been of practical value. It gives the writer pleasure to acknowledge this indispensable assistance by Messrs. W. W. Yothers, R. A. Cushman, A. C. Morgan, C. R. Jones, W. D. Pierce, F. C. Pratt, F. C. Bishopp, W. H. Gilson, and J. C. Crawford.

W. E. H.

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SOME FACTORS IN THE NATURAL CONTROL OF THE MEXICAN COTTON BOLL WEEVIL.

INTRODUCTION.

The natural control of the cotton boll weevil is so broad a subject, comprising the effects of so many factors, some of which are imperfectly known and understood, that anything like a comprehensive treatment of the subject is at present impossible. Doubtless many factors of some importance have not yet been studied. Of the fact that some factors do accomplish the destruction observed in individual cases we have no doubt. From extensive series of such observations we may be able to reason safely as to the general tendency of those factors, and we may possibly be able to assign to them a relative value in their tendency to control under the conditions then prevailing, but we must recognize the fact that all these factors, however many there may be, are so interrelated and their influences under varying conditions may so essentially differ that a study of them becomes an exceedingly difficult problem.

CONDITIONS REQUIRING CONSIDERATION.

The magnitude of the work involved is directly increased by the extent of the area affected and by the variations in climatic, geological, and cultural conditions which are encountered within the weevil-infested area. While some factors may be studied through multiplied observations as to their effect in individual cases, others must be considered from the broader standpoints of the general movement of the species, crop production, etc.

Temperature and moisture conditions are undoubtedly the principal climatic factors which govern in a general way the distribution of every species. Of these two factors, temperature is unquestionably the more important. The effect of this factor upon the continued spread of the boll weevil has been a subject of interest to entomologists ever since the weevil became a factor in the cultivation of cotton in Texas. It has been supposed that the weevil, coming originally from a habitat much farther south, would finally be checked by this temperature factor, and it was hoped that this would occur before the northern limit of profitable cotton production should be reached. Unfortunately, the insect has shown that it is capable of a considerable amount of adaptation to this change in temperature conditions, so that its northward range has been gradually extended until, in the season of 1906, it crossed the Red River Valley and became established in the southern portion of Indian Territory. Humidity has proved to be an important factor, affecting more the abundance and injuriousness of the species than it does its distribution.

Considering some of the broader aspects of the effect of temperature and humidity in controlling the weevil, it appears that the most marked instances of definite control have been occasioned by what may be termed the unusual variations, either above or below the usual range, in these factors. Thus it seems to be prolonged periods of extreme heat in summer and the exceptional depression in temperature in winter which have produced the most clearly marked results. When these exceptional conditions occur, they affect, as a rule, rather extensive areas, so that the good results are general instead of localized, as is likely to be the case with many of the factors which will be considered in succeeding pages. The possible effect of high summer temperatures has been the prime reason for recommendations designed to secure a proper spacing of the plants, which would leave weevil-infested squares most directly exposed to the sunshine. It frequently happens that this factor is sufficiently effective to so check severe weevil attack as to allow the cotton to set and to mature a reasonably good crop. It is especially effective if occurring early in the season during the period when the plant is normally setting its crop of fruit. Its value may be completely neutralized by other coincident or preceding conditions, such as a very rank growth of the plants, or a too close planting, which may cause the plants to shade a large proportion of the fallen forms.[a]

INFLUENCE OF SHORT DROUGHT IN SAME SEASON.

A definite illustration of the control of the weevil, largely by prolonged and excessive heat, was found at Victoria, Tex., in 1906. The plat of cotton under observation covered only one-half acre, so that it was possible to make frequent and close observations upon the conditions prevailing on the entire plat. Table I presents a brief summary of temperature, rainfall, crop, and weevil conditions for this area during a period of four months from the planting of the seed.

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[a] The term "forms" is used for convenience to include all stages of the cotton fruit: The bud or square, the bloom or flower, and the boll or seed pod.

TABLE I.—*Temporary control of weevil by drought in May and June, Victoria, Tex., 1906.*

Month.	Temperature.				Precipitation.			Weevil and crop conditions.
	Absolute maximum.	Monthly mean maximum.	Monthly mean average.	Departure from normal.	Number of rainy days.	Total rainfall.	Departure from normal.	
1906.	°*F.*	°*F.*	°*F.*	°*F.*		*Inches.*	*Inches.*	
April..	87	79	70.3	−2.4	6	2.88	+0.22	Cotton planted early in month. Stand uneven.
May...	96	86	76.4	−1.6	2	.63	−3.29	Cotton began squaring about May 20. Weevils coming from hibernation in large numbers. No blooms, as all squares are destroyed as formed.
June...	103	94.3	83.7	+1.5	2	.68	−3.03	Weevils still coming from hibernation. No blooms until very last of month. First generation weevils nearly all destroyed while immature. Number of weevils in field greatly decreased by June 30. Blooms and bolls then forming abundantly.
July...	97	91.2	82.9	−1.3	12	4.93	+1.73	Weevils so checked by June conditions that before they could multiply again a good crop was set and a yield of about one-half bale was gathered in September and October.

It should be noted that in this field a considerable portion of the ground was exposed to sunshine through the unevenness of the stand. The rainfall during April was sufficient to give the plants a good start, and a fair growth was made through the month of May. April and May were somewhat cooler than is usual for those months. The weevils which had passed through hibernation in the vicinity of the field were so abundant early in the season that squares became infested as rapidly as they were formed. Squares began to form before May 1, but no blooms appeared, and conditions seemed to point to the inevitable failure of the crop until after the extreme heat and drought of June. During June the maximum temperature recorded was below 90° upon only one day, when it was 88° F. On three days the maximum temperature recorded was above 100° F. The mean maximum temperature for the month, 94.3°, is therefore exceptionally high. During the seventy-four days between April 20 and July 3 rains fell upon only four occasions and the total precipitation was less than $1\frac{1}{3}$ inches. This extreme heat and drought produced a very marked change in the weevil conditions found in this field. Through the gradual dying off of hibernated adult weevils and the long-continued destruction of their progeny, the number of weevils to be found in the field was very greatly reduced. Following the heavy and well distributed rains occurring in July, the plants quickly put out large numbers of squares, and before the weevils could multiply so as to do any considerable damage the plants had set a normally good crop of fruit. While weevils became numerous later in the season, a yield of nearly one-fourth of a bale was obtained from this half-acre plat.

The beneficial effect of this drought during the squaring season in Victoria County may be shown by a comparison of the yields for the seasons 1903 to 1906, inclusive. These figures as given by the Bureau of the Census in equivalent 500-pound bales are as follows:

Yields of cotton in Victoria County, Tex., 1903–1906.

Year.	Bales.
1903	5,355
1904	6,495
1905	9,016
1906	16,963

INFLUENCE OF A DRY SEASON UPON SUCCEEDING SEASON.

The duration of the dry period as related to the growing season of cotton determines primarily whether the beneficial effect shall be prolonged beyond one season. In the case cited at Victoria drought occurred only in the first third of the season, and its effect was upon the immediate crop, but the benefit would not be continued into the following year. In some of the dryer regions of cotton production it is not unusual to have an entire season covered by a period of comparative drought, and under such conditions the effect upon weevil abundance is quite different. Several illustrations of this have occurred in the region between Corpus Christi and San Antonio, Tex. One of the most definite instances is here given by way of illustration. In this case the effect was widespread, and may be judged by a comparison of rainfall, temperature, and crop conditions for Nueces County, Tex., during the years 1901–1904.

TABLE II.—*General illustration of drought control, Nueces County, Tex., 1901–1904.*

Year.	Rainfall.				Temperature.				Cotton production, Nueces County, equivalent 500-pound bales.
	Annual.		Mar. 1–Aug. 31.		Annual.		Mar. 1–Aug. 31.		
	Total.	Departure from normal.	Total.	Departure from normal.	Mean average.	Departure from normal.	Mean average.	Departure from normal.	
	Inches.	*Inches.*	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	
1901	17.49	−11.90	6.74	− 7.42	70.7	0.0	76.2	0.83	601
1902	22.22	− 7.98	5.57	− 7.39	71.5	+ 1.4	77.3	+1.85	480
1903	36.92	+ 6.72	25.97	+11.38	69.1	− 0.9	74.5	− 0.9	4,099
1904	28.54	− 1.66	13.56	+ 0.83	70.5	+ 0.4	76.0	+ 0.5	1,556

In connection with this table it should be noted that the temperature conditions during the six months which are of greatest significance varied but little from the normal. In rainfall, however, a great deficiency occurred both in 1901 and in 1902. Undoubtedly the continuance of the drought throughout the season was more influential than was the boll weevil in reducing the crop for the years 1901 and 1902, which were almost complete failures. Through the season of 1903 there fell a large excess of rain and it was well distributed. This would produce conditions very favorable for weevil multiplication and injury, but in spite of this the cotton crop for 1903 for this county was nearly ten times as large as during the preceding year. In 1904 both temperature and rainfall were nearly normal, but the effect of the large number of weevils passing through hibernation from the season of 1903 is very conspicuously shown by the reduced size of the crop of 1904. This is an illustration of the control of the boll weevil by the unfavorable climatic conditions of an entire season so effective that the weevil failed to become greatly injurious to the succeeding crop in a season when the climatic conditions were unusually favorable for its increase.

CONTROL BY WINTER CLIMATIC CONDITIONS.

Exceptionally low winter temperatures have occasionally proved sufficiently effective to exterminate the weevils from certain areas which had become recently infested and within which the weevils had not had time to become firmly established. This has been illustrated by several well established cases in northern Texas and Louisiana during the past few years.

Weevils were first found near Sherman, Tex., in the fall of 1903, when the northern limit of the dispersion reached to within a few miles of that place. No weevils could be found in that region in 1904 or until the dispersion of 1905 had taken place, thus proving that the few weevils reaching there in 1903 had failed to reproduce or that they and their progeny were completely exterminated by the winter conditions of 1903–4. Weather Bureau records show that the minimum temperature in this locality during the winter of 1903–1904 was 12° F. on January 26, 1904, and that the average monthly temperatures for January, February, and March at Sherman were +2.6°, +10°, and +6.9° above normal, respectively. It hardly seems probable, therefore, that the weevils failed to maintain themselves in this case solely on account of low winter temperatures.

Through the dispersion movements during the fall of 1904 weevils spread over a large area in western Louisiana, as shown on the accompanying map (fig. 1).

By a large number of very careful field examinations between May 1 and August 1, 1905, Mr. Wilmon Newell, entomologist of the Louisiana State crop pest commission, with the assistance of Messrs. E. S. Hardy, J. B. Garrett, W. O. Martin, and C. W. Flynn, working in cooperation with the boll weevil investigation of the Bureau of Entomology, was able to determine that the weevils had been practically, if not completely, exterminated in that portion of the 1904-infested area lying east of the heavy line shown in the map, running from the southwestern corner of Caddo Parish, through about the

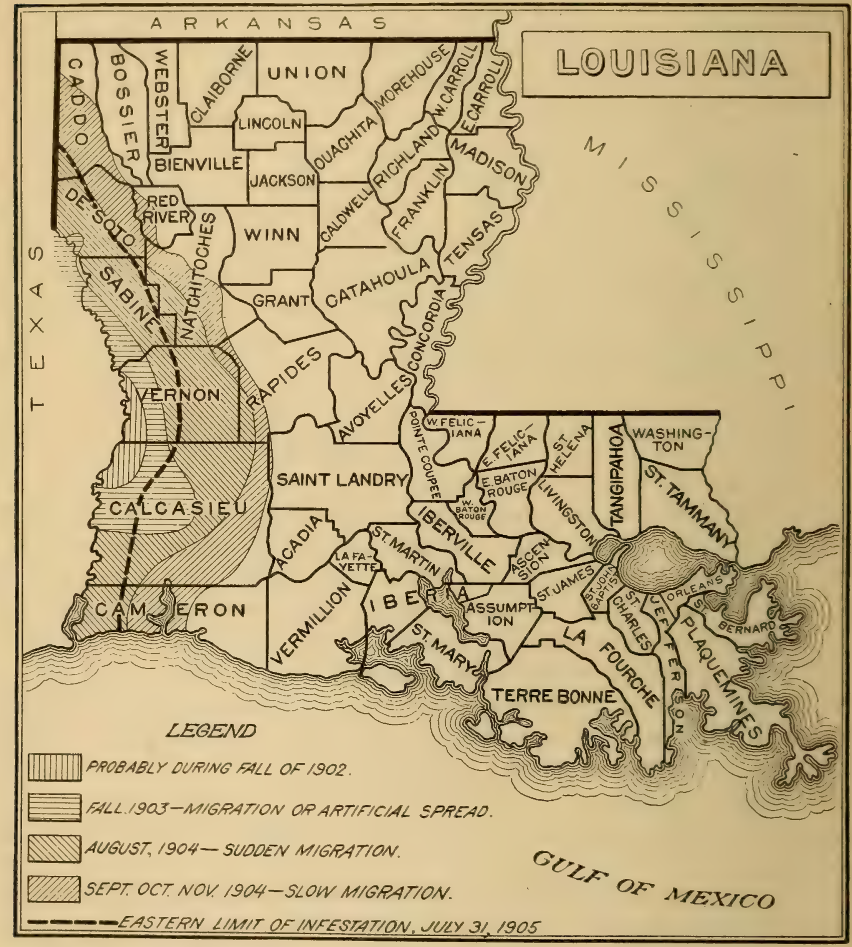

FIG. 1.—Map of Louisiana, showing dispersion movements of 1903 and 1904 and reduction of infested area by winter conditions of 1904–1905.

middle of De Soto, Sabine, and Vernon parishes and the western third of Calcasieu and Cameron parishes, nearly parallel to the western boundary of the State. In other words, through the unfavorable climatic conditions following the dispersion of 1904 the weevil was exterminated throughout practically two-thirds of the area in Louisiana which had first become infested by the weevil dispersion of that year. From the reports from Louisiana of the Weather Bureau for 1904 and 1905 it appears that killing frosts occurred generally through the State about November 13 to 15, 1904. The temperature and rainfall conditions within the infested area from that time till the end of December were not far from normal, though the rainfall during December was very heavy east of the infested area. During January the temperature in the infested area averaged about 5 degrees below the normal, while in February it reached an extreme departure, averaging 9 degrees below normal. During these two months the rainfall in this area was very heavy, averaging more than 10½ inches. Though this appears to be not more than 1 or 2 inches in excess of the normal rainfall during these two months, it is far more than the weevil has been obliged to withstand, as a usual occurrence, in Texas, and in conjunction with the very exceptionally low temperatures it probably explains in large measure the extermination of the weevils through practically all of the territory entered by them in the fall of 1904 after the latter part of August. It remains to be seen whether the heavy winter rainfall which normally occurs in this Louisiana territory will, as a usual thing, prove to be an important factor in reducing the number of weevils hibernating successfully within this area.

A somewhat similar reduction of infested area occurred in northern Texas coincident with that in Louisiana, but, owing to the demands of other lines of investigation in Texas, it was impracticable to make as thorough an investigation to determine the limit of infestation in July, 1905, in Texas as was done in Louisiana.

As the weevil seems to be acquiring a greater power of resistance to low temperatures as it spreads farther northward, the value of this factor for any locality now included within the weevil-infested area would seem to be gradually decreasing. The efficiency of winter cold is very largely affected by the coincident humidity and by the abundance and favorable character of the opportunities for shelter which may be obtained by the hibernating weevils.

Besides the direct effect upon weevil survival, winter climatic conditions exercise an indirect effect upon weevil injury during the following season by their influence upon the survival of cotton roots. This is an especially important consideration in southern Texas, where during many seasons a considerable proportion of old roots survive, giving rise in the spring to what is variously termed sprout, stubble, or seppa cotton. These sprouts arising from roots which are already established begin growing, as a rule, before cotton is planted. Their growth is exceptionally vigorous, so that these plants frequently produce squares several weeks in advance of the average planted crop. This source of food supply, occurring so early in the season, serves to sustain a large number of hibernated weevils from the time of their emergence until after the planted cotton becomes susceptible to their attack. It also furnishes early emerged weevils with opportunities for reproduction, which may produce a large number of first generation weevils by the time planted cotton begins to form squares. It has been noticed that during seasons when an exceptional amount of sprout cotton occurs weevil injury has, as a rule, been exceptionally severe. The increased injury during such seasons is undoubtedly traceable to two primary causes: (1) The climatic conditions which are most favorable to the survival of cotton roots are also as favorable to the survival of hibernating weevils; (2) the large numbers of weevils surviving under these conditions are provided with an abundant food supply and with early opportunities for reproduction by the sprout cotton which occurs.

During winters when the climatic conditions are unfavorable both for the survival of weevils and for the survival of old cotton roots the smaller number of weevils emerging in the spring find no other food supply than that provided by the planted cotton, and can not begin their reproductive activity until such time as the squares upon the planted cotton may be about one-half grown. Under these conditions the crop has a fair opportunity to set before weevils become sufficiently abundant to destroy a large proportion of the rapidly forming squares.

It is difficult to understand why so many planters fail to appreciate the importance of preventing entirely the appearance and growth of sprout cotton. The only way in which its occurrence may be positively prevented in all seasons and in all parts of the infested area is by the uprooting of the old plants. It is plain that the most effective time to do this, so far as securing a reduction in the number of weevils is concerned, is immediately following the maturity and picking of the crop. This prevents further multiplication of weevils at that time and removes the available food supply of those which are adult as long as may be possible before they can hibernate successfully. Extensive experiments and observations have shown that if the stalks be thoroughly destroyed (as by burning) from three to four weeks before the occurrence of the first frost in the fall and if the ground be kept clean, so that favorable opportunities for shelter are removed, the number of weevils surviving hibernation may be very greatly reduced. If by any chance sprout cotton appears in the spring, every plant of it should be destroyed to prevent its nourishing the weevils which may have survived. The practice of allowing sprout cotton to grow in a field of planted cotton can not be too strongly condemned. Certainly if planters could appreciate the fact that these occasional plants will, under usual conditions, enable the weevils to do much greater injury to the main crop, they would be very careful to destroy them. If planters in southern Texas fully appreciated the importance of this menace, there would soon be developed a strong public sentiment which would compel every planter to adopt methods which would prevent the occurrence of sprout cotton. It is entirely possible in a great majority of cases for the planter to insure for himself the beneficial effect of a large reduction in the number of weevils surviving hibernation, such as would result from occasional winters of unusual severity, even during seasons which would be favorable for the survival of large numbers of weevils. This, then, is the part of cultural practice which may be made to regularly supplement or possibly supplant the beneficial effects which are occasionally experienced by an exceptionally large degree of natural control through severe climatic conditions during the winter.

RELATIONSHIP OF FACTORS OF CONTROL.

It is evident that these factors, which are but the extreme fluctuations in climatic conditions, will only occasionally exert their maximum effect, and that under normal conditions of temperature and humidity other factors, having a more constant average efficiency, may surpass climatic variations in their controlling effect upon the weevil. It is to a study of some of these average factors that the present paper will be mainly devoted. Among the factors concerned in the natural control of the boll weevil in the United States to which especial attention has been given may be mentioned heat or drying, native ants, proliferation, parasites, the limitation of the weevil's food supply by the work of the cotton leaf-worm (*Alabama argillacea* Hbn.), and birds.

In this bulletin special consideration will be given to the effects of heat or drying, native ants, and parasites. Proliferation[a] was studied extensively in 1905, and the most important results of the investigation have been published.[a]

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[a] "Proliferation," as the term is used in connection with cotton, refers to a phenomenon which frequently follows the attack of weevils or other insects in cotton squares and bolls. It may be defined as the development of numerous elementary cells from parts of the bud or boll which are themselves normally the ultimate products of combinations of much more highly specialized cells. The resulting product is thus composed of comparatively large, thin-walled cells, which are placed so loosely together that the formation is of soft texture and has a granular appearance which may be seen with the naked eye. Proliferous formations lack the distinctive texture which is characteristic of the normal parts of either bud or boll. The consistency of the formation is soft and yielding, resembling somewhat a rather soft gelatin. From this apparent resemblance the term "gelatinization" is sometimes used instead of proliferation.

The work of parasites and the possibility of making them even more valuable in the fight against the weevil is considered fully by Mr. W. D. Pierce in another bulletin of this Bureau.[b] The relationship of birds to the boll weevil has been treated in several publications, principally by the Biological Survey.[c]

The study of the influence of the leaf worm upon weevil control will require at least another season before the results can be sufficiently complete for publication.

The work with proliferation was continued in 1906 only as far as seemed advisable to confirm preceding results and conclusions. It was found in 1905, in over 8,000 examinations, that proliferation produced an increase in weevil mortality, averaging, for squares and bolls together, about 12.5 per cent. From the data following in these pages it appears that there is an average mortality not attributable to heat or drying, ants, or parasites, among over 80,000 observations of squares and bolls together, averaging slightly over 12 per cent. The confirmation of previous conclusions is evident, but in reference to both it should be stated that the figures recorded must be considered as a conservative statement of the value of this factor, since it must be admitted that it may become effective in many cases even before the hatching of the weevil eggs and that it is practically impossible in a large series of examinations to determine whether an egg or very small larva of the weevil may have been destroyed. It must also be considered that proliferation resulting from feeding punctures of the weevil and of other insects frequently proceeds to such an extent as to itself accomplish a destruction of both squares and bolls entirely disproportionate to the severity of the feeding injury which originally incited the proliferation. The value of proliferation as a factor in controlling the weevil is therefore offset in some degree by its tendency to continue beyond the remedial point and by its abundant formation under certain conditions of irritation when no weevil stage is present.

The work with parasites has been sufficiently extensive to form a very reliable basis for further investigations which promise to give increasingly valuable results. The actual records of parasitism and the comparisons between this and other factors of natural control are given herewith, while the more special consideration of the conditions favoring parasite abundance, the biological study of the species found, and the possibility of increasing their effectiveness may be found as given by Mr. W. D. Pierce in Bulletin No. 73 of the Bureau of Entomology.

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[a] Bul. No. 59, Bureau of Entomology. (See p. 8 for bibliography of proliferation.)

[b] Bul. No. 73, Bureau of Entomology.

[c] Bul. No. 51, Bureau of Entomology, pp. 150–153; Buls. Nos. 22, 25, and 29, Biological Survey.

For many years the cotton leaf worm (*Alabama argillacea*) has been considered as an important cotton pest throughout the South, though the severity of its injury to the crop has been less during recent years than it was formerly. It now appears in destructive numbers only during the latter part of the season, usually after the crop begins to mature, and is not infrequently a welcome visitor. Especially in rank late cotton its destruction of the foliage enables light and air to penetrate more readily, thus preventing the decay of bolls lying on or near the ground and greatly facilitating the maturity of the crop. For this reason comparatively few planters now look upon the leaf worm as a pest to be controlled by the application of insecticides. Succeeding generations of the caterpillars remove an increasingly large proportion of the foliage until the plants may be finally stripped bare repeatedly before the close of the season.

The significance of the leaf worm in the control of the boll weevil rests directly upon its effect upon the food supply of the latter species. As the weevil has no other food plant than cotton, its final multiplication before the end of the season is usually limited directly by the abundance of squares and bolls within which it may breed. The defoliation of the cotton by the leaf worm stops immediately the formation of squares and the subsequent possibility of the setting of bolls. Further development of the weevils is thus abruptly checked. The maturing bolls may continue to give out weevils for some weeks, and previously infested squares may add to the number of adult weevils for from one to two weeks, but the sudden removal of the food supply and of the shelter usually enjoyed by the adults causes great mortality among them. Many weevils leave the bare fields in search of food, and thus, in various ways, the number of weevils in a field where the leaf worms work abundantly and thoroughly becomes very greatly reduced. If the leaf worms continue to strip the cotton until late in the fall there will be no possibility of an increase in the number of weevils. The leaf worms may actually accomplish what is practically a more or less complete early destruction of the cotton plants and a cleaning up of leaf rubbish in the field. Where this is the case it is safe to assume that so few weevils will survive or hibernate that a very positive benefit may be experienced during the following season, and if climatic conditions should favor the growth of cotton, a crop may be secured with comparatively little injury by the weevil.

Defoliation by the leaf worm may be especially effective if it should happen to be followed by winter climatic conditions which are exceptionally severe, so that only those weevils which found the most favorable hibernation shelter would naturally survive. The leaf worm does not, however, often occur abundantly during two successive seasons in Texas. Its work is often local and only partial in the field attacked. Frequently the plants leaf out and form squares after having been defoliated. It must, therefore, be placed rather low in the list of factors concerned in the natural control of the boll weevil.

It is possible that something can be done to increase the efficiency of this factor or to render it of more constant value, especially in such regions as the Red River valley of Louisiana, where the worm occurs with considerable regularity. It is evident, however, that the planter should not rely upon the leaf worm to secure the destruction of his stalks at as early a date as the picking of the crop may render possible. At present in the bulk of the infested territory it may be considered as an occasionally valuable factor, but the completeness of the control resulting from its occasional work is a most valuable demonstration of the effect which it is possible for the planter to secure quite regularly by himself destroying the food supply of the boll weevil early in the fall.

The irregularity of the leaf-worm attack makes it necessary that final conclusions as to its value in controlling the weevil be based upon observations extending over a number of years, but the data already collected show conclusively that with these two important pests of cotton present in abundance the leaf-worm work is a most positive benefit to the planter; and if it secures continuous defoliation until too late in the season for the weevil to resume its breeding, this may result in the practically complete control of the insect for the following season.

There can be no doubt that birds are an important factor in preventing the extraordinary multiplication of many species of insects. Considerable attention has been given to the determination of the value of various birds as destroyers of weevils, and this important work is being continued by the Biological Survey. These records show that birds do not yet constitute a very important factor in controlling the boll weevil. There are several reasons for this. The habits of the weevil are such that the adults are but slightly exposed to the attack of birds, except during the season of the fall dispersion.

In Cuba Mr. E. A. Schwarz has determined that a bird (*Icterus hypomelas*) has learned to tear open the fallen squares and eat the weevil stages infesting them, but in the United States no bird has yet acquired such a habit. The season at which birds capture most weevils is during the dispersion in the fall months, when the weevils are flying most abundantly. The destruction of a large number of weevils late in the season can not, however, be as effective in controlling the weevil as would be the capture of a comparatively few during the hibernation season or in early spring, but during the first half of the season very few birds frequent the cotton fields. For these reasons birds must be ranked low among the controlling factors, but it is possible that they will gradually acquire an increasing importance the longer the weevil remains abundant.

There are other factors which are, or may become, of relatively great importance in the fight against the weevil. Some of these have been but slightly investigated. It is safe to assume that the factors which have been mentioned include those which have thus far proved to be of greatest importance in holding the weevil in check to some extent.

The relative value of these factors is certain to change suddenly, and when one assumes a position of predominant influence the others must undergo a readjustment of relative position. It is certain that the efficiency of predaceous enemies and of parasites is gradually increasing, while it is probable that the gradual adaptation of the weevil to its new environment is rendering it more resistant, especially to the effects of the adverse climatic factors. Additional observations of the effects of these opposing tendencies should bring to light facts which will be of general significance in connection with the study of many other pests besides the boll weevil.

The area infested by the boll weevil in the United States now reaches a total of between 175,000 and 200,000 square miles. Of course but a small percentage of this enormous acreage is actually devoted to cotton culture, but the range in geological conditions is naturally great. Thus in Texas cotton is cultivated extensively on five or six very distinct geological areas each furnishing more or less distinctive conditions of environment affecting faunal, floral, and shelter conditions which may at any time prove to have an important significance in the weevil status.

INVESTIGATIONS SHOWING CONTROL BY HEAT, ANTS, AND PARASITES.

Observations of the effect of various natural factors in controlling the weevil have been accumulating since the beginning of the boll weevil investigation. The earlier records, however, were not made to include the simultaneous effect of several factors, and the records presented in this connection are therefore confined to the observations made during 1906.

Heat and drying are considered together, as their effects upon the immature weevil stages are coincident and inseparable. The efficiency of this factor naturally follows seasonal variations, but it is largely affected by the distance between rows, the size of the plants and density of their foliage, the season of occurrence in relation to the state of the cotton crop, and by cultural conditions.

Whenever ants are referred to in succeeding pages it should be understood that no reference is intended to the Guatemalan "kelep" (*Ectatomma tuberculatum* Oliv.), which has failed to maintain itself in Texas.

The native ants concerned in the control of the weevil are principally of the genus Solenopsis and varieties of the species *geminata* (fig. 2).

The principal points in the characterization of this species are as follows: There are two distinct nodes or scales in the slender petiole of the abdomen. All forms but the male have a sting (Pl. II, fig. 2). The antennæ (Pl. II, fig. 3) are ten-segmented; the club is formed of the last two segments, of which the terminal one is the longer. Maxillary and labial palpi have each two segments. The clypeus has two longitudinal ridges and the sting is very large. The color varies, but the workers usually seen are of a dark reddish brown, the color of the abdomen being often considerably darker than that of the head and thorax. Length of workers from 2 to 3 mm.

These ants form nests near the surface of the ground. All stages of development and forms of adults may be found in these nests practically throughout the summer season. The individuals which are most active, if not in fact those which are alone concerned in the attack upon the weevil, are the smaller workers which are commonly to be seen outside of the nests. In Plate II, figures 5 and 6, are shown some of the immature stages of this species. The queen larvæ are very much larger than the worker forms as is shown in the illustration. The pupæ are naked, and as they approach maturity the color gradually changes from a translucent white to a dark brown. The active worker form is shown in Plate II, figures 1 and 4.

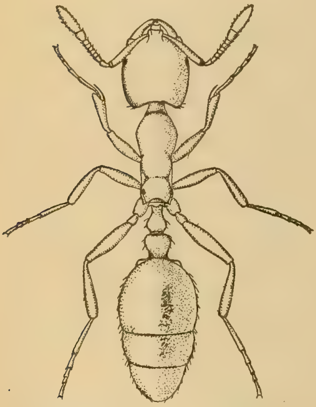
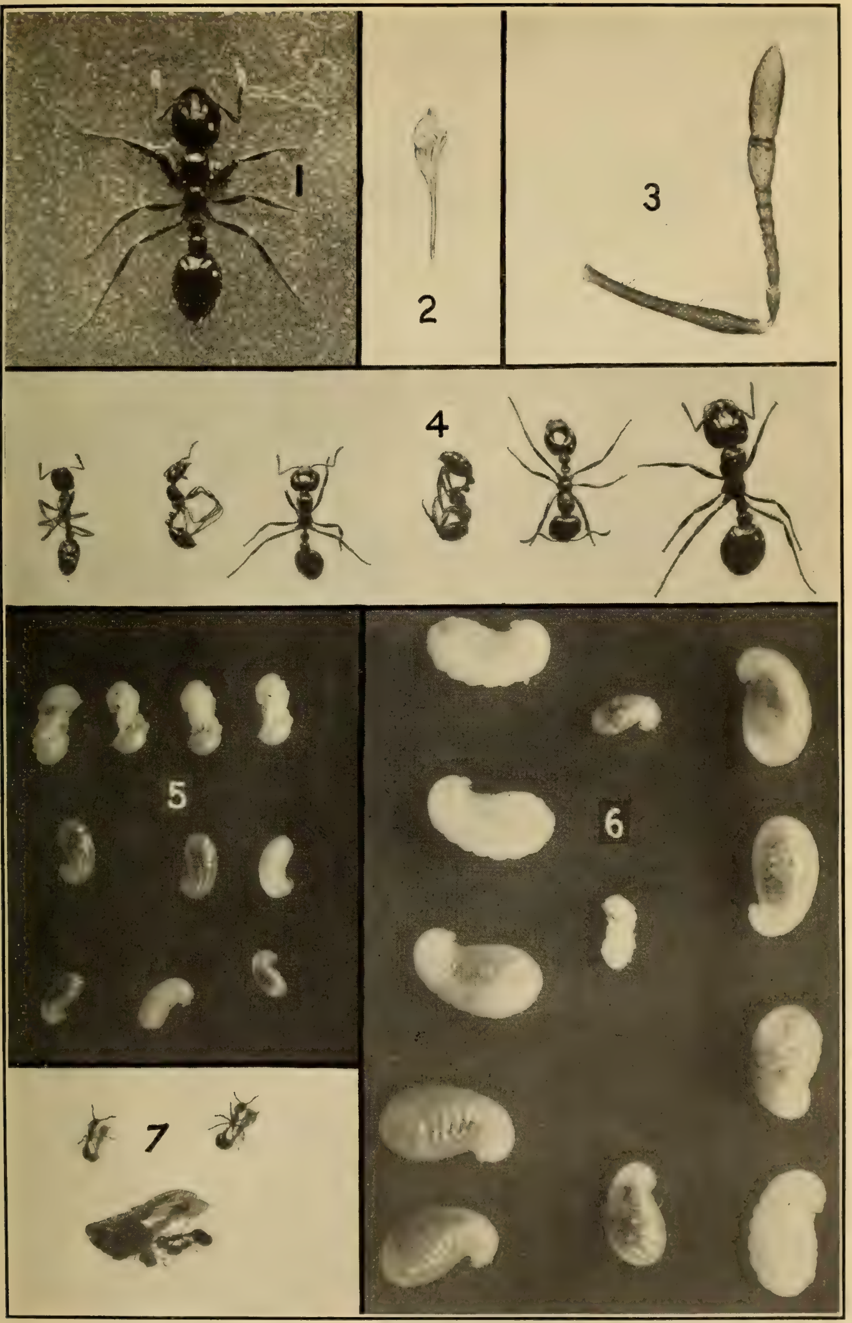


FIG. 2.—*Solenopsis geminata*, ant enemy of boll weevil. Much enlarged (from Hunter and Hinds).

This species shows a tendency to nest within the shade formed by the plants, and is to some extent out of the reach of ordinary cultivation by being close to the middle of the rows. The breaking up of a nest, however, does not seem to drive them away or to interfere seriously with their activities. In Plate III, figure 2, are shown cotton squares which have been entered by these ants and in which weevil stages have been destroyed. A comparison of the external resemblance of these entrance holes with the exit holes made by weevils is shown in Plate III, figures 1 and 2.

Since, in external appearance, the emergence holes made by adult weevils in escaping from squares resemble very closely the entrance holes made by the Solenopsis ants in obtaining access to the weevil stages in a square, it seems advisable to add a brief explanation of the manner in which these two classes of squares may be positively separated. In all cases the final determination as to the class in which a square belongs rests upon an examination of the interior. As



STAGES AND CHARACTERISTICS OF SOLENOPSIS GEMINATA.

Fig. 1.—Adult, small worker form. Fig. 2.—Sting of worker. Fig. 3.—Right antenna of worker. Fig. 4.—Adult workers, various sizes from workers minor to workers major. Fig. 5.—Larvæ and pupæ of small forms of worker. Fig. 6.—Larvæ of queens compared with larva and pupa of small forms. Fig. 7.—Workers dragging off adult boll weevil which they have killed. Fig. 1, enlarged to 7 diameters; figs. 2 and 3, to 40 diameters; figs. 4, 5, and 6, to 4 diameters; fig. 7, to 2 diameters. (Original.)

a general thing the emergence hole made by the weevil (Pl. III, fig. 1) is more regular in outline and somewhat larger in area than are the entrance holes made by the ants. Upon opening the square carefully it will be found that if a weevil has reached full development therein and emerged, there will be found present three definite signs which are not present in cases where ants have destroyed the weevil stage. One of these signs is the delicate white skin which is shed by a pupa when the weevil transforms from that stage to its adult condition. (Pl. III, fig. 5*a*.) This is usually so shriveled and twisted as to have no resemblance whatever to the outlines of a living pupa and is frequently more or less hidden in the débris which constitutes the second sign. This is a rather abundant mass of fine particles which have been torn from the square by the weevil in cutting its emergence hole. These are not eaten by the weevil but are left within its cell (Pl. III, figs. 3 and 5*b*). The third sign of adult activity consists of a number of particles of white excrement which are almost invariably deposited by the adult weevil before its emergence from the square (Pl. III, figs. 3 and 5*c*). These three signs are absent in cases where ants have entered and destroyed the weevil stages (Pl. III, fig. 4).

The value of a study based upon statistical data becomes easily apparent to one engaged in a thorough study of such a subject as this. Without it there is a strong probability that the general impressions formed may not give proper credit to the influence of the various factors. Conclusions which are based upon the total effects of the various factors in a large series of observations must necessarily be more reliable. This must be especially true of the general average of results from a considerable number of localities and under a considerable variety of geological and climatic conditions.

The first division in the data as obtained has been secured by separating the cotton fruit into several classes, each of which may contain weevil stages which have been exposed to similar conditions. But four of these divisions have been retained in the arrangement of the data shown in Table III. These are, (*a*) hanging, dried bolls; (*b*) hanging, dried squares; (*c*) fallen bolls; (*d*) fallen squares. As a rule infested squares and small bolls are shed by the plant in from seven to twelve days after the weevil attack. Many small bolls, especially, are shed normally, even though they may have suffered no injury from insect attack. This happens most commonly within a few days after the withering of the flower and before the young boll has made any growth. It may result from a failure in fertilization of the flower or the inability of the plant to sustain an excessive load of fruit. With both squares and small bolls, the shedding is accomplished naturally, just as is the shedding of leaves in the autumn, by the formation of an absciss layer of corky cells which cuts off the fibrovascular bundles through which the sap is supplied, thus destroying the vital connection between the bud or boll and the plant branch. The exact location of this cork area is shown by the scar left by a fallen leaf or square. It frequently happens, however, that for some reason the severance is incomplete and that the square or boll remains slightly attached to the plant though cut off as far as the vital connection is concerned (Pl. IV, figs. 2 and 3*b*). The difference in these two conditions may be seen and better understood by reference to Plate IV, figures 1 and 2.

The tendency to retain dead squares and bolls seems to be a characteristic of individual plants in nearly all varieties, but is most strongly marked in those which approach the limbless, cluster type of growth. In some fields the hanging, dried forms may be found very abundantly, while in others at the same time they may be very rare.

The retention of squares and bolls bears no definite relationship to the boll weevil injury, as many of the small bolls, especially, have never been attacked.

It is evident that the immature weevil stages in those forms which remain hanging upon the plant will be subjected to very different influences by the factors of natural control from those in fallen forms. This difference is especially marked as regards the exposure to the effect of sunshine and to the attacks of predaceous and parasitic enemies, and should be kept in mind in considering the data presented in the following tables.

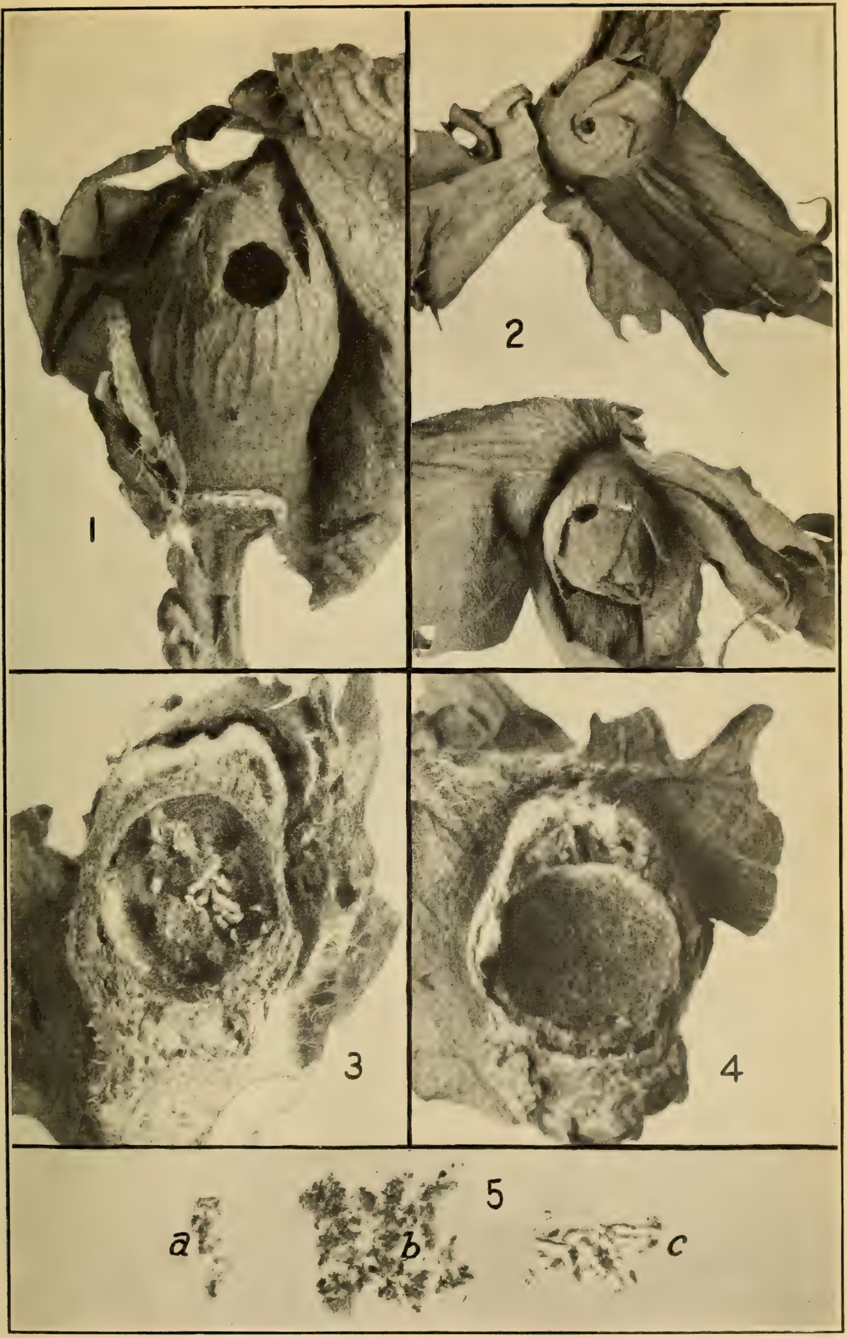
An explanation should also be given regarding the counting of stages. Besides each weevil stage, living or dead, which was actually found, one stage was counted for each case where there existed unquestionable evidence of its previous presence. This evidence would include the emergence hole made by an adult weevil, the cell within a square or boll from which some stage of the weevil had been removed by ants, and also the cases of parasitism. Since dead stages accumulate through a considerable period of time, or so long as the forms remain intact, and will be found and counted upon examination, it becomes necessary in determining percentages of mortality to count emergence holes as representing living adults which, of course, is really the case.

It would require too much space to give the detailed results of each of the examinations made. For each locality, therefore, all the observations made have been combined. This means in most cases that the figures given in these tables represent an average of several fields in each locality, and in seventeen of the twenty-eight localities where observations were made the figures combine the results of examinations upon from two to nine dates.

NATURAL CONTROL IN VARIOUS CLASSES OF FORMS.

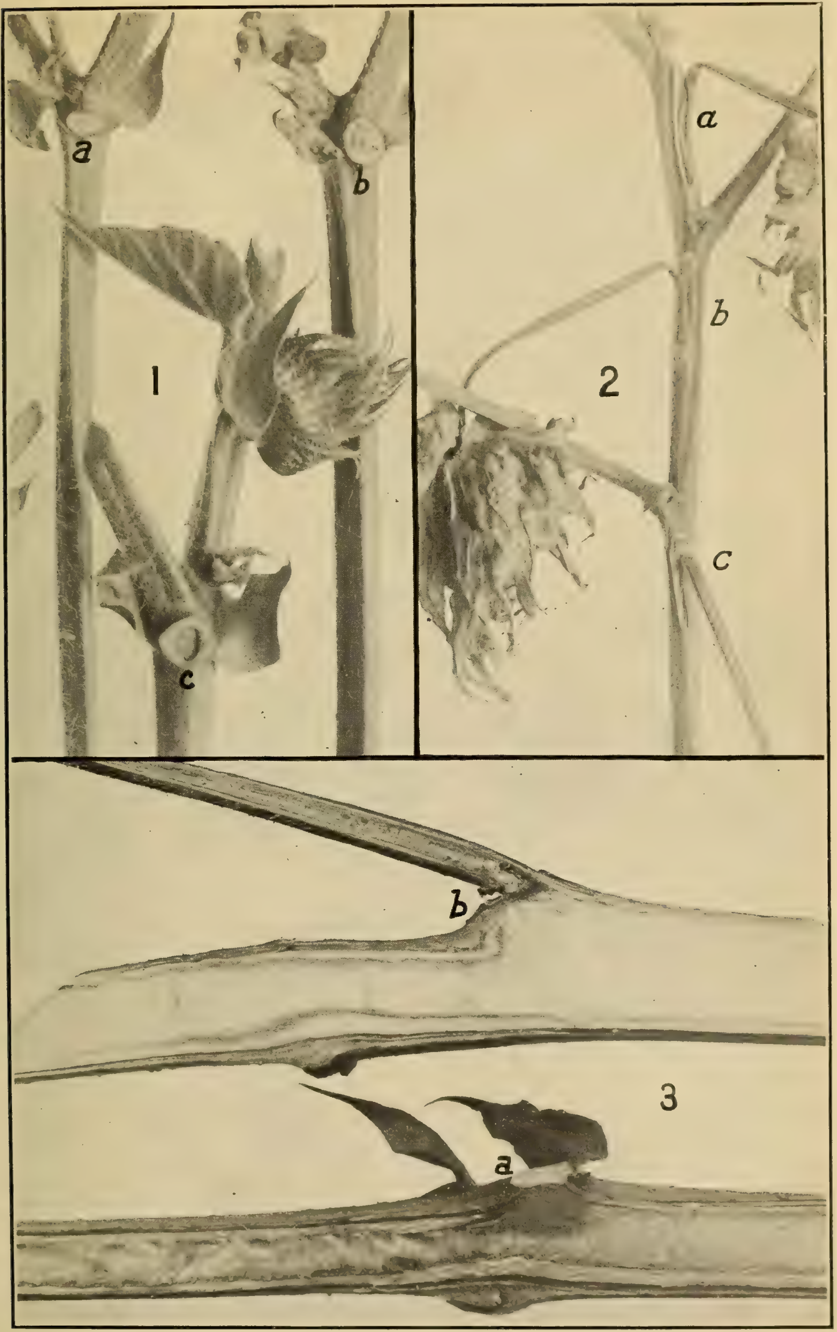
In collecting the forms for these examinations all were taken as they came, whether fallen, or dried and hanging to the plants. The green, growing forms were not examined.

Separate collections were made to secure hanging or fallen forms.



SIGNS DETERMINING BOLL WEEVIL EMERGENCE OR ENTRANCE OF ANT SOLENOPSIS GEMINATA.

Fig. 1.—Emergence hole of boll weevil in cotton square. Fig. 2.—Entrance holes of ants in squares. Fig. 3.—Evidences of adult activity in square from which weevil emerged. Fig. 4.—Clean interior of square entered by ants. Fig. 5.—The three evidences of adult weevil activity, removed from square: *a*, Shed pupal skin; *b*, refuse formed in cutting emergence hole; *c*, excrement of unfed, young adult. All, except fig. 2, enlarged to 4 diameters; fig. 2, enlarged to 2 diameters. (Original.)



SHEDDING AND RETENTION OF FORMS IN COTTON.

Fig. 1.—*a, b, c*, Normal scars left by shed forms. Fig. 2.—*a, b, c*, Abnormal scars with forms retained. Fig. 3.—*a*, Longitudinal section through normal scar; *b*, longitudinal section through base of retained form. Fig. 1, natural size; fig. 2, somewhat reduced; fig. 3, enlarged to 2 diameters. (Original.)

TABLE III.—*Mortality of weevils.*

A. MORTALITY IN HANGING, DRIED BOLLS.

Locality.	Date.	Total number of forms examined.	Weevil stages alive.				Stages killed by heat or drying.			Evident cause of death.						Total weevil stages.		
					Adults.					Heat or drying.		Ants.		Parasites.				
			Larvæ.	Pupæ.	Present.	Emerged.	Larvae.	Pupæ.	Adults.	Number of stages.	Per cent of total stages.	Number of stages.	Per cent of total stages.	Number of stages.	Per cent of total stages.	Number found.	Number found dead from three causes.	Per cent of mortality from three causes.
Louisiana:	1906.																	
Mansfield	Sept. 24–29	1,705	38	47	77	112	18	19	22	59	9.4	199	31.9	37	6.0	624	295	47.3
Many	Aug. 23	1,250	43	103	84	117	25	21	32	78	14.5	53	10.0	32	6.0	539	163	30.2
Texas:																		
Calvert	Aug. 22–Sept. 13	901	17	35	41	23	17	2	1	20	11.5	25	13.8	12	6.6	181	57	31.5
Corsicana	Aug. 23	1,250	29	40	26	44	14	0	0	14	8.0	13	7.4	6	3.4	176	33	19.0
Cuero	Aug. 9–31	276	88	29	26	8	1	1	2	4	2.1	25	13.2	2	1.0	189	31	16.4
Dallas	Aug. 29–Oct. 15	4,604	144	243	239	255	38	11	18	67	4.9	232	17.0	67	4.9	1,362	366	27.0
Goliad	Aug. 7–Sept. 3	530	81	53	52	32	1	3	0	4	1.5	20	7.5	13	4.9	265	37	14.0
Hallettsville	Aug. 9–30	1,240	71	67	61	24	19	2	1	22	8.1	16	5.9	11	4.0	273	49	18.0
Marshall	Aug. 22	173	12	9	5	8	4	0	0	4	7.7	7	13.5	7	13.5	52	18	34.6
Overton	Aug. 23	210	9	15	8	10	4	2	1	7	7.8	32	36.0	4	4.5	89	43	48.3
Palestine	Aug. 10	510	77	46	23	27	6	0	0	6	2.8	8	3.8	7	3.3	211	21	10.0
San Antonio	Aug. 15	310	0	0	0	0	0	0	0	0	0.0	1	100.0	0	0.0	1	1	100.0
Taylor	Aug. 16	125	20	11	1	3	0	0	0	0	0.0	2	5.0	1	2.5	40	3	7.5
Trinity	Aug. 9–30	1,330	64	59	17	45	7	2	3	12	4.5	27	10.0	28	10.4	269	67	25.0
Victoria	Sept. 1	315	68	27	30	16	12	2	5	19	9.5	48	23.4	1	0.5	201	68	33.8
Waco	July 25–Oct. 12	2,630	55	72	137	268	70	8	32	110	11.4	194	20.1	94	9.8	961	398	41.4
Total		17,359	816	856	827	992	236	73	117	426	7.8	902	16.6	322	6.0	5,433	1,650	30.4
B. MORTALITY IN HANGING, DRIED SQUARES.																		
Louisiana:	1906.																	
Mansfield	Aug. 24	435	1	2	5	61	27	13	10	50	20.3	119	48.4	7	2.8	246	176	71.6
Many	Aug. 23	833	2	42	27	186	79	27	19	125	20.8	155	25.8	63	10.5	601	343	57.1
Texas:																		
Calvert	Aug. 22–Sept. 13	207	6	5	2	11	21	3	0	24	29.6	20	24.7	8	10.0	81	52	64.2
Corsicana	Aug. 23	125	4	9	7	12	18	2	2	22	25.9	19	22.4	12	14.1	85	53	74.1
Cuero	Aug. 9–31	931	97	60	40	16	85	4	1	90	20.6	32	7.3	87	20.0	438	209	48.0
Dallas	Aug. 29–Oct. 6	225	5	13	7	41	18	0	0	18	16.4	19	17.3	9	8.2	110	46	41.7
Goliad	Aug. 7–Sept. 3	337	7	25	20	59	14	3	2	19	9.1	48	23.0	29	13.9	209	96	46.0
Hallettsville	Aug. 9–30	602	16	45	80	53	38	8	9	55	13.8	110	27.6	37	9.3	399	202	50.6

TABLE III.—*Mortality of weevils*—Continued.

B. MORTALITY IN HANGING, DRIED SQUARES—Continued.

Locality.	Date.	Total number of forms examined.	Weevil stages alive.				Stages killed by heat or drying.			Evident cause of death.						Total weevil stages.		
			Larvæ.	Pupæ.	Adults.		Larvae.	Pupæ.	Adults.	Heat or drying.		Ants.		Parasites.		Number found.	Number found dead from three causes.	Per cent of mortality from three causes.
					Present.	Emerged.				Number of stages.	Per cent of total stages.	Number of stages.	Per cent of total stages.	Number of stages.	Per cent of total stages.			
Texas—Continued:	1906.																	
Overton	Aug. 23	56	1	0	1	8	1	0	0	1	2.2	33	73.3	1	2.2	45	35	77.8
Palestine	Aug. 10	468	24	94	56	57	51	11	5	67	17.2	37	9.5	48	12.3	390	152	40.0
Roosevelt	Sept. 25	216	20	19	5	10	6	1	0	7	8.6	18	22.2	2	2.5	81	27	33.3
San Antonio	Aug. 15	91	8	0	0	2	0	0	0	0	0.0	24	70.6	0	0.0	34	24	70.6
Taylor	Aug. 16	116	21	23	12	3	7	2	0	9	11.4	2	2.5	8	10.0	79	19	24.1
Trinity	Aug. 9-30	276	5	16	8	28	26	6	2	34	20.0	49	29.0	21	12.4	169	104	61.5
Victoria	July 2 and Sept. 1	1,158	119	161	69	83	140	10	8	158	19.7	111	12.6	82	10.2	802	351	31.3
Waco	July 25-Oct. 12	928	9	23	6	78	113	3	9	125	27.1	87	18.9	126	27.3	461	338	73.3
Total		7,004	345	537	345	708	644	93	67	804	19.0	883	20.9	540	12.8	4,230	2,227	52.6
C. MORTALITY IN FALLEN BOLLS.																		
Louisiana:	1906.																	
Mansfield	Aug. 24-Sept. 29	1,222	40	17	13	30	28	5	1	34	16.1	77	36.5	0	0.0	211	111	52.6
Many	Aug. 23	1,089	103	53	46	49	3	4	7	14	4.4	47	14.6	5	1.6	321	66	20.2
Orangeville	Aug. 23-Sept. 30	295	13	8	9	11	2	2	2	6	9.0	17	25.4	0	0.0	67	23	34.3
Texas:																		
Beeville	July 12 and Aug	2,116	75	33	26	22	60	7	4	71	22.0	92	28.4	0	0.0	324	163	50.3
Brownsville	July 28-Sept. 5	1,820	69	59	69	107	18	2	8	28	7.3	24	6.3	13	3.4	384	65	17.0
Calvert	Aug. 28-Sept. 13	913	203	113	9	2	2	1	0	3	0.9	4	1.2	0	0.0	347	7	2.0
Corpus Christi	July 10	321	8	8	2	1	1	0	0	1	5.0	0	0.0	0	0.0	20	1	5.0
Corsicana	Sept. 18	310	2	1	0	3	9	8	3	20	58.5	4	11.8	2	5.9	34	26	76.5
Cuero	Aug. 31	282	16	10	0	3	18	6	2	26	32.5	25	31.3	0	0.0	80	51	63.7
Dallas	Aug. 29	367	51	10	0	0	0	0	0	0	0.0	9	12.9	0	0.0	70	9	12.9
Fullers	Aug. 17	382	3	0	0	1	0	0	0	0	0.0	0	0.0	0	0.0	4	0	0.0
Goliad	Sept. 3	488	64	29	8	11	9	1	1	11	8.3	5	3.8	3	2.3	133	19	14.2
Hallettsville	Aug. 30	902	11	2	2	4	18	5	4	27	29.0	46	49.5	1	1.1	93	74	79.6
Junction	Sept. 24	44	5	2	0	1	3	0	0	3	17.6	5	29.4	1	6.0	17	9	53.0
Kerrville	Aug. 26-Sept. 3	500	215	41	10	2	9	0	0	9	3.1	7	1.4	7	1.4	295	23	7.8
Lula	Sept. 26	46	26	11	1	0	0	0	0	0	0.0	7	13.7	0	0.0	51	7	13.7

Marshall	Aug. 22	227	8	2	0	0	6	2	0	8	44.4	0	0.0	0	0.0	18	8	44.4
Mineola	Oct. 2	158	21	12	2	0	6	5	3	14	24.6	7	12.3	1	1.8	57	22	38.1
Overton	Aug. 23	375	29	9	5	0	4	0	0	4	4.4	44	48.4	0	0.0	91	48	52.7
Palestine	Aug. 10–Sept. 4	578	128	31	15	13	11	0	0	11	5.2	5	2.8	1	0.5	209	17	81.3
Roosevelt	Sept. 24	46	59	8	1	1	0	0	0	0	0.0	3	4.1	0	0.0	74	3	4.1
Taylor	Aug. 16	310	21	8	0	1	0	0	0	0	0.0	0	0.0	0	0.0	34	0	0.0
Terrell	Sept. 19	220	30	11	1	0	0	0	0	0	0.0	3	6.5	0	0.0	46	3	6.5
Trinity	Aug. 9–30	4,390	279	69	24	32	122	12	8	142	14.5	403	40.3	4	4.0	976	549	56.2
Victoria	June–Sept	2,351	171	53	6	3	17	9	0	26	9.2	19	6.8	0	0.0	281	45	16.0
Waco	July 25–Oct. 12	2,933	110	43	15	31	27	23	19	69	18.1	98	25.7	7	1.8	381	174	45.6
Total		22,685	1,760	643	264	328	373	92	62	527	11.4	951	20.6	45	1.0	4,618	1,523	33.0

D. MORTALITY IN FALLEN SQUARES.

Louisiana:	1906.																	
Johnsons Bayou	Aug. 22–27	300	106	80	19	17	0	1	0	1	0.4	1	0.4	0	0.0	225	2	0.9
Mansfield	Aug. 24–Sept. 29	962	36	31	12	104	46	18	6	70	14.6	218	45.3	2	1.2	481	290	61.1
Many	Aug. 23	2,008	105	218	48	325	60	16	6	82	6.6	479	37.9	5	0.4	1,367	566	44.7
Orangeville	Aug. 23–Sept. 30	900	89	71	25	58	5	2	0	7	1.6	161	37.0	5	1.1	435	173	42.1
Texas:																		
Beeville	July–Oct.	3,312	83	70	31	69	422	71	18	511	19.2	1,774	67.1	36	1.3	2,644	2,321	87.8
Brownsville	July 28–Sept. 9	7,142	105	423	321	439	989	145	49	1,183	38.2	380	12.3	194	6.3	3,095	1,757	56.8
Calvert	Aug. 28–Sept. 13	1,386	88	349	132	93	9	7	1	17	1.6	105	10.0	15	1.5	1,037	137	13.2
Corpus Christi	July 10	718	12	20	8	30	162	17	2	181	41.3	124	28.3	16	9.0	438	321	73.3
Corsicana	Sept. 18	26	1	0	0	1	3	1	0	4	25.0	10	62.5	0	0.0	16	14	72.5
Cuero	Aug. 31	1,550	13	18	8	17	455	110	12	577	54.7	340	32.1	11	2.4	1,059	928	87.6
Dallas	Aug. 29	111	14	8	0	7	2	0	0	2	3.6	23	42.6	0	0.0	54	25	46.2
Fullers	Aug. 17	100	20	0	0	1	0	0	0	0	0.0	0	0.0	0	0.0	21	0	0.0
Goliad	Sept. 3	1,305	65	74	52	90	166	68	7	241	29.4	198	24.1	70	8.5	821	509	60.8
Hallettsville	Aug. 30	1,380	18	15	1	17	380	76	12	468	44.0	474	45.6	5	4.8	1,040	947	91.1
Junction	Sept. 24	383	11	10	2	22	33	1	3	37	28.7	33	25.6	11	8.5	129	81	62.8
Kerrville	Aug. 26–Sept. 3	46	14	10	0	0	1	0	0	1	3.0	6	17.1	4	11.4	35	11	31.4
Lula	Sept. 26	278	22	12	6	3	2	0	0	2	3.6	3	5.6	0	0.0	54	5	0.9
Marshall	Aug. 22	52	7	4	1	0	3	0	1	4	17.4	7	30.4	0	0.0	23	11	47.6
Mineola	Aug. 10–Oct. 2	917	116	60	7	26	72	61	11	144	32.4	83	18.7	9	2.0	445	236	53.0
Overton	Aug. 23	312	5	6	0	2	11	4	1	16	8.1	166	84.3	2	1.0	197	184	93.3
Palestine	Aug. 10–Sept. 4	1,335	323	408	62	75	131	24	1	156	14.9	6	0.3	14	1.3	1,048	176	16.8
Roosevelt	Sept. 24	88	16	13	5	7	8	1	0	9	13.8	10	14.5	9	13.0	69	28	40.6
Taylor	Aug. 16	246	74	38	8	3	27	0	0	27	17.0	0	0.0	1	0.7	153	28	52.9
Terrell	Sept. 19	88	26	19	2	3	1	0	0	1	1.9	0	0.0	0	0.0	53	1	1.9
Trinity	Aug. 9 and 30	2,641	403	115	34	92	105	13	2	120	7.7	641	41.3	18	1.2	1,552	779	51.0
Victoria	June–Sept	8,004	1,054	384	121	303	1,787	53	8	1,848	28.5	2,010	31.0	200	3.1	6,488	4,058	52.5
Waco	July 25–Oct. 12	4,318	205	153	66	110	483	71	38	592	34.2	554	32.0	151	8.8	1,731	1,297	75.0
Total		39,908	3,031	2,609	971	1,914	5,363	760	178	6,301	25.6	7,806	31.7	778	3.2	24,710	14,885	60.5

From a study of the totals in each section of this table it appears that the highest average percentage of mortality from all three causes considered was found among the fallen squares, where it reached 60.5 per cent. The next highest average mortality occurred in the hanging, dried squares, with 52.6 per cent. The mortality in the two classes of bolls is very similar, with 33 and 30.4 per cent.

The data include only examinations of cotton forms which had been destroyed by some cause. In the majority of cases the destruction of the form could be attributed directly to weevil attack. The data upon this point are stated in subsequent tables. (See pp. 64–72.)

A comparison of the mortality records in hanging versus fallen forms (including both squares and bolls) shows that among the 9,663 stages found in hanging forms there was an average mortality of 40 per cent, while among the 29,328 stages in fallen forms there was an average mortality of 56 per cent. In hanging bolls the mortality is 30.4 per cent; in fallen bolls, 33 per cent; in hanging squares, 52.6 per cent; in fallen squares, 60 per cent. These figures show a consistent difference in favor of the fallen forms.

Parasites work more freely in the forms that remain attached to the plants than in those which fall to the ground, but in neither class of forms is their work as important as is that of the ants or even the effect of heat or drying. From many observations as to the stage of the parasite at the time of examination and from a general knowledge of the time that must have passed between it and the parasite attack, it appears that, as a rule, the parasite egg is deposited at about the time the square or boll withers. If this be the case, it is probable that the increased length of time during which the forms that remain attached and dry upon the plant are exposed to the parasite attack may explain the greater percentage of parasitization found in the hanging forms. In hanging forms parasitization amounts to 9 per cent, while among fallen forms it averages only 2.8 per cent.

The average total mortality among all classes of forms caused by the three factors was 52 per cent. As the weevil does not pass beyond the influence of these factors of control until after it has become adult and emerged from the square or boll, it is evident that among the 13,000 living stages found present there might still have occurred a very considerable mortality before all could have become adult and emergence taken place. The larval and pupal stages, which number over 80 per cent of all the living stages found present, are especially susceptible to the influence of the three natural factors of control under consideration. It would be very conservative to assume that fully one-half of the living stages present would have been destroyed had the forms been allowed to remain exposed to the influence of the factors of control until all surviving adults could have emerged. This would have increased the destruction of weevil stages by these factors to about 68 per cent.

DESIRABILITY OF RETENTION OR SHEDDING OF INFESTED FORMS.

Still another arrangement of general results may serve to show a comparison between the four classes of forms and between hanging and fallen forms. This arrangement is given in Table IV. It may serve to indicate for the entire infested area whatever general advantage there may be to the plant in the shedding or in the retention of its infested forms.

TABLE IV.—*Summary of mortality results shown in Table III, hanging and fallen forms.*

Class of fruit.	Total number of forms examined.	Total weevil stages found.	Weevil stages dead.		Cause of death.						Proportion of forms to each weevil stage.
					Heat or drying.		Ants.		Parasites.		
			Total number.	Per cent of total stages found.	Number of stages killed.	Per cent of total found.	Number of stages killed.	Per cent of total found.	Number of stages killed.	Per cent of total found.	
Hanging forms:											
Dried, hanging bolls	17,359	5,433	1,650	30.4	426	7.8	902	16.6	322	6.0	3.20
Dried, hanging squares	7,004	4,230	2,227	52.6	804	19.0	883	20.9	540	12.8	1.66
Totals, hanging forms	24,363	9,663	3,877	40.2	1,230	12.9	1,785	18.7	862	9.0	2.52
Fallen forms:											
Fallen bolls	22,685	4,618	1,523	33.4	527	11.4	951	21.0	45	1.0	4.91
Fallen squares	39,908	24,710	14,885	60.8	6,201	24.7	7,806	32.8	778	3.3	1.62
Totals, fallen forms	62,593	29,328	16,408	56.4	6,728	23.0	8,757	30.0	823	2.8	2.13
Summary of all forms:											
Hanging forms	24,363	9,663	3,877	40.2	1,230	12.9	1,785	18.7	862	9.0	2.52
Fallen forms	62,593	29,328	16,408	56.4	6,728	23.0	8,757	30.0	823	2.8	2.13
Totals, all forms	86,956	38,991	20,285	52.3	7,958	20.5	10,542	27.2	1,685	4.3	2.23

The possibility of weevil damage having any relation to the retention of forms by the plant may be settled by a study of the proportion of weevil stages to each class of forms.

The last column of the table shows the average proportion of each class of forms to one weevil stage found. It must be borne in mind that many squares and bolls are destroyed by the feeding of the weevils in which no eggs have been deposited. Undoubtedly in a great many cases a young larva may have died when no trace of its presence could be found at the time the examination was made. This would especially apply to the hanging forms. From the proportions given it appears that, among hanging forms, twice as many bolls were examined for each weevil stage found as in the case of squares, while among fallen forms the proportion is three to one. This indicates that there is practically no difference in the proportion of weevil stages to squares, whether hanging or fallen, but that there is a natural tendency on the part of the plant to shed a large number of uninfested bolls soon after their formation and before weevil attack has taken place. Many of the dried hanging bolls also fail to show any sign of weevil attack. The attack of the weevils upon squares is, therefore, of much greater importance in their multiplication than is their attack upon bolls. Here again the importance of natural control is shown by the mortality in all squares, amounting to almost 60 per cent, whereas in all bolls it was but 31.6 per cent.

These figures show a remarkable similarity in the degree of infestation for the corresponding classes of fruit. This agreement is so close as to lead to the conclusion that the attack of the weevil has practically no effect upon the tendency of the plant to retain a portion of its surplus fruit in this way.

The proportion of hanging to fallen forms is not accurately shown by the figures given here as no effort was made to collect the hanging and fallen forms from the same areas at each examination made. This proportion varies very greatly in different fields and during different periods of the season, but it is safe to say that in the examinations recorded a much larger proportion of hanging, dri[illegible] was collected than would be found in any ordinary field of cotton, unless it were of some limbless variety, such as the Dickson. Among the forms examined, nearly 70 per cent of the squares and bolls had fallen. These fallen forms contained somewhat more than 70 per cent of all the weevil stages found. The proportion of weevil stages to forms is very closely similar in hanging and in fallen forms, but the percentage of mortality in hanging forms averages 40, while in the fallen forms it averages over 56 per cent. The relative importance of the mortality in the two classes of forms as related to the whole question of natural control is shown to a fair degree by a comparison of the percentages of mortality in hanging versus fallen forms, based upon the total number of stages found in the total number of forms examined. In this way we find that among the 38,891 weevil stages found the 3,877 dead in hanging forms constitute approximately 10 per cent, while the 16,408 dead in fallen forms constitute 42.1 per cent. Since, as has been stated, the hanging forms examined are in a greater proportion to the fallen forms than actually occurs in the average field, it follows that it is conservative to say that, as a rule, the total mortality in fallen forms will average to be, at least, four times as great as that occurring in the hanging forms. Consequently the factors of natural control which affect especially the weevil stages in the fallen forms must be given a correspondingly high rank as compared with those which affect more especially the stages in the hanging forms. Figuring in this way for each of the three factors of natural control given, we find that heat or drying caused a mortality of 3.2 per cent in hanging forms and 17.5 per cent among fallen forms, ants caused a mortality of 4.6 per cent among hanging forms and 22.4 per cent among fallen forms, while parasites caused a mortality of 2.2 per cent among hanging forms and only 2.1 per cent among fallen forms.

The conclusions may also be drawn from a study of the proportion of weevil stages found dead in each class of forms, in connection with the factors causing death and the proportion of forms to weevil stages in each class examined. In this way it appears that the lowest total mortality was found in the hanging bolls which dried upon the plant, being in this case 30.4 per cent. For fallen bolls this percentage was 33.4, in hanging squares there was a mortality of 52.6, while in fallen squares it amounted to 60.8 per cent. Taking next a comparison of hanging and fallen forms, it appears that there was an advantage during the season of 1906 of 16.2 per cent greater total mortality among the fallen forms.

As to the factors which were most effective in producing this mortality, it appears that among hanging forms ants produced 46.5 per cent of the total mortality found, while in fallen forms they were responsible for 53.2 per cent of the total mortality. It is evident, therefore, that in either hanging or fallen forms *Solenopsis geminata* was the most important summer factor in 1906 in controlling the weevil. When it is considered that a large majority of the infested forms fall, it becomes still more certain that the effectiveness of the factors naturally tending to control weevil multiplication is greater when the infested forms are shed than when they are retained by the plant.

From these data it appears that it is more desirable that plants shed their infested forms completely and quickly after the infestation takes place than that they should retain them, allowing the weevil stages therein to develop under the smaller influence of natural control to which they would then be subjected.

MORTALITY IN BOLLS VERSUS SQUARES.

It should be stated that in these examinations no attempt was made to determine the mortality among weevil stages in large bolls which continued their development in spite of the weevil attack. In such bolls it is obvious that heat or drying can have had little if any effect upon the weevil stages. Ants do not enter green, growing bolls, though they frequently destroy weevil stages which become more easily exposed to their attack through the opening of the bolls. Instances have been found of parasitism of weevil stages in large bolls. Proliferation is, however, an active factor which has been found in the examination of more than 12,000 locks to produce an increase in mortality of weevil stages amounting to between 6 and 7 per cent.

For this comparison the figures given in Table III are combined for bolls and for squares.

TABLE V.—*Mortality in bolls versus squares.*

	Total forms examined.	Total weevil stages found.	Per cent of stages alive.	Per cent of mortality caused by—			Per cent of total mortality, three factors.
				Heat.	Ants.	Parasites.	
Bolls	40,044	10,051	64.5	9.5	18.4	3.6	31.6
Squares	46,912	28,940	36.1	24.5	30.0	4.6	59.1

Several general conclusions may be drawn from the study of these figures. In bolls nearly two-thirds of all the stages found were alive, while in squares the living stages constituted but slightly more than one-third of the total stages found. Heat is about two and two-thirds times as effective against the weevil stages in squares as against those in bolls. Ants are also much more effective in raising the mortality in squares. Parasites are slightly more active in attacking weevil stages in squares than in bolls, but the difference in this case is much less than in the case of ants or heat. From the combined effect of these three factors there is a total mortality averaging in bolls a little less than one-third, and in squares nearly three-fifths, of all weevil stages present.

Among the 38,991 weevil stages found, 63.5 per cent of this total number occurred in fallen squares. It is evident, therefore, that the factors of natural control which are most effective in destroying weevil stages in fallen squares are the most important in restricting the summer multiplication of the weevil. It appears that the Solenopsis ants and heat are the two most important factors in this connection.

In these examinations it was impossible to account for eggs and very small larvæ, as the drying of much of the material and the decay present in another large portion would inevitably efface all traces of these stages even in cases where the work of the living larvæ was not sufficient to have done so. In the absence of positive data showing the mortality in these young stages, no attempt will be made to estimate the mortality that undoubtedly does occur early in the weevil's development. It is certain that the average of the smallest larvæ found would not be more than one-third or possibly one-fourth grown, but the data given for the stages above the one-third grown larva are thoroughly reliable.

It is therefore safe to say that the mortality of the boll weevil throughout the infested area, as represented by twenty-eight well-distributed localities, during the period from June 16 to October 15, 1906, from the effects of heat or drying, ant, and parasite attack averaged not less than 65 or 70 per cent of all the weevil stages surviving beyond six or seven days from the deposition of the eggs. If to this percentage we add the 12 per cent which were found dead from some cause other than the three under consideration, but principally due to proliferation, we have a total mortality of from 75 to 80 per cent.

The average length of the developmental period from June to October is shown in Bulletin 51, Bureau of Entomology, page 94, to be between eighteen and twenty days. The mortality shown by these records occurs, therefore, during the last two-thirds of the period between the deposition of the egg and the emergence of the adult weevil. When it is considered that a considerable proportion of eggs and very young larvæ must also be destroyed, it becomes increasingly apparent that but a very small percentage of the total number of eggs deposited by the weevils in a field of cotton produce adults.

It may seem that this tremendous destruction of weevil stages would be sufficient to bring the weevils under practical control so that the comparatively small remainder would produce little injury to the crop. Such, however, is not the case. The fact is that in nearly if not quite all of the fields examined the weevils were so abundant as to destroy a large portion of the crop, and in most cases it is probably true that the multiplication of the weevils was finally limited by the amount of food supply present rather than by the destruction of the weevil stages by all these factors of natural control. This does not mean that the crop did not benefit by the destruction of weevil stages accomplished, for had it not been for this checking of the possible multiplication of the weevils few of the fields could have produced a crop that would have been worth the picking.

Were it not for the fact that in nearly all cases the destruction of the weevil stage occurs only after the weevil has destroyed the cotton form, the crop might be much more largely benefited by this natural control. Without the natural control existing, cotton production within the weevil-infested area would be impossible; with it alone, the continuance of cotton culture may still be possible; but only by supplementing the work of nature by the most practicable methods known can the balance be thrown largely in favor of the planter in producing a very profitable crop.

NATURAL CONTROL IN VARIOUS LOCALITIES.

In the sections of Table III the data are divided according to the class of forms examined in order to make apparent the varying differences in the effects of the several factors of natural control upon the weevil stages in each class of forms. In studying the combined effect, which is really the measure of control in any locality and for any period of time, this separation into classes is no longer necessary. For this reason the figures given in Table VI represent a combination of the four classes given in Table III. It is proposed to show for each locality the proportion of the total mortality due to each of the three factors, a comparison of the mortality in each stage of the weevil—larva, pupa, and adult—and the general climatic conditions prevailing during the period covered by the examinations. In this way it may be possible to show whether any particular combination of climatic conditions prevailed in coincidence with the highest percentages of mortality found, or whether the percentages may vary widely under similar climatic conditions so that the real explanation for the variation must be due to other causes than climatic differences. In this table, as in Table III, the percentage of mortality in *larval*, *pupal*, and *adult* stages is based upon the total numbers of those stages which were found alive or which had died from the effects of heat or drying. It seemed impracticable to attempt the determination of the stage of the weevil destroyed by ants and parasites, though in many cases it would have been possible. The "total of weevil stages found" includes those found alive, those killed by heat or drying, and those which had died but probably from some other cause than heat, and each weevil cell emptied by ants as well as each instance of parasite occurrence.

In the column showing "total mortality from three causes" it may be seen that the range is from 0 to 84 per cent, with the average at 52 per cent. Eleven localities show a mortality above the average and seventeen below it. For the eleven the average mortality is 63.2 per cent, while for the seventeen the average is but 34.2 per cent. It is noticeable that nearly all of those showing the higher percentages are located below or south of the center of cotton culture in Texas. The figures in Table VI show the conditions for mortality by these three factors, and also give in each locality and in a general way the climatic conditions prevailing during the period of examination and for ten or fifteen days previously. In cases where no records are available, those are used for a near-by locality having weather conditions probably similar to those of the locality in which the examinations were made. The totals in this table show the general facts concerning mortality under average conditions in the twenty-eight localities representing in a general way the infested area. Besides the comparison as to mortality by each of the three factors represented there is a general record showing the mortality found in each stage of the weevil from heat or drying. The records of the four principal classes of forms examined are combined in this table.

It is shown that the mortality from heat in the larval stage amounts to 52.6 per cent, in the pupal stage to 18 per cent, and in the adult stage to 6.3 per cent. Nearly 70 per cent of all the mortality caused by heat or drying occurs, therefore, during the larval stage. An early shedding of infested forms is plainly very desirable.

TABLE VI.—*Comparison of mortality records from heat or drying, ants, and parasites for Louisiana and Texas in 1906.*

Locality.	Date or period.	Total of four classes of forms examined.	Total weevil stages found.[a]	Total stages killed by heat, ants, and parasites.	Total mortality from three causes.	Percentage of mortality from—			Mortality from heat or drying[b] among weevil stages.						Climatic conditions.[c]						
									Larva.		Pupa.		Adult.			Temperature.			Rainfall.		
						Heat or drying.	Ants.	Parasites.	Number of this stage found.	Per cent of this stage dead.	Number of this stage found.	Per cent of this stage dead.	Number of this stage found.	Per cent of this stage dead.	Period included.	Mean maximum.	Mean average.	Departure from normal.	Total rainfall.	Departure from normal.	Number rainy days.
Louisiana:	1906.				P. ct.	P. ct.	P. ct.	P. ct.		P. ct.		P. ct.		P. ct.	1906.	°F.	°F.	°F.	In.	In.	
Johnsons Bayou	Aug. 22-27	300	225	2	0.9	0.4	0.4	0.0	106	0.0	81	1.2	36	0.0	....	.....	.....	.....	.....	.....	....
Mansfield	Aug. 24-Sept. 29	4,324	1,562	872	56.1	13.6	39.2	3.2	234	50.1	152	36.2	453	8.6	Aug. 1-Sept. 30	89.7	78.9	+ 1.5	7.37	......	16
Many	Aug. 23	5,180	2,828	1,138	40.2	11.0	26.9	4.0	420	40.0	484	14.0	946	7.0	Aug. 1-31	92.9	80.6	......	0.58	−2.79	2
Orangeville	Aug. 23-Sept. 10	1,195	502	196	39.4	2.6	35.5	1.0	109	6.4	83	4.8	105	2.0	Aug. 1-Sept. 30	89.4	80.2	+ 2.0	6.01	−1.31	9
Texas:																					
Beeville	July 12-Oct. 1	5,428	2,968	2,484	84.0	20.0	62.8	1.2	640	75.3	181	43.1	170	12.9	July 1-Aug. 31	94.2	83.8	−1.35	5.49	+1.42	12
Brownsville	July 28-Sept. 5	8,962	3,479	1,822	52.5	34.8	11.6	6.0	1,181	85.3	629	23.7	993	5.7	July 1-Aug. 31	92.2	84.1	+0.9	8.83	+3.88	12
Calvert	Aug. 22-Sept. 13	3,407	1,646	253	15.1	3.9	9.3	2.1	363	13.5	515	2.5	315	0.6	Aug. 1-Sept. 30	94.6	83.7	+1.5	10.22	+6.10	25
Corpus Christi	July 10	1,039	458	322	70.3	40.0	27.1	3.5	183	88.0	45	37.7	43	2.3	July 1-31	88.8	83.0	+1.3	0.41	−0.91	3
Corsicana	Aug. 23-Sept. 18	1,711	311	126	40.5	19.3	14.8	4.5	80	55.0	61	18.2	98	5.1	Sept. 1-30	90.9	79.7	+1.6	2.53	−0.71	7
Cuero	Aug. 9-31	3,039	1,766	1,219	69.0	39.5	23.9	5.7	773	72.3	238	50.9	135	12.6	Aug. 1-31	94.5	83.8	−1.0	2.43	+0.77	4
Dallas	Aug. 29-Oct. 15	5,307	1,596	446	28.0	5.5	17.7	4.7	272	21.3	285	3.8	567	3.2	Aug. 1-31	90.8	80.0	−3.2	4.25	+2.38	8
Fullers	Aug. 17	482	25	0	0.0	0.0	0.0	0.0	23	0.0	0	0.0	2	0.0	Aug. 1-31	90.8	80.0	−3.2	4.25	+2.38	8
Goliad	Aug. 7-Sept. 3	2,660	1,428	661	46.3	19.3	19.0	8.5	407	46.7	256	30.0	334	3.0	Aug. 1-31	90.2	81.6	−0.9	4.52	+2.14	6
Hallettsville	Aug. 9-31	4,124	1,805	1,272	70.0	31.7	35.8	3.0	571	80.0	220	41.4	268	10.0	Aug. 1-31	95.0	84.6	+1.1	0.85	−1.54	3
Junction	Sept. 24	427	146	90	61.6	27.4	25.4	8.2	52	69.2	13	9.2	28	8.9	Sept. 1-30	90.9	79.0	+3.5	4.44	+2.80	7
Kerrville	Aug. 25-Sept. 3	546	330	34	10.3	3.0	4.0	3.3	239	4.2	51	0.0	12	0.0	Aug. 1-31	95.3	82.4	+1.2	3.47	+1.90	9
Lula	Sept. 26	324	105	12	11.4	2.0	10.0	0.0	50	4.0	23	0.0	10	0.0	....	.....	.....	.....	.....	.....	....
Marshall	Aug. 22	452	93	37	40.0	17.2	16.1	7.5	40	32.5	17	11.8	15	6.7	Aug. 1-31	88.7	79.3	......	2.65	......	7
Mineola	Aug. 10-Oct. 2	1,075	502	258	51.4	31.5	17.9	2.0	215	36.4	138	48.0	49	28.4	....	.....	.....	.....	.....	.....	....
Overton	Aug. 23	953	422	310	73.5	6.6	65.2	1.7	64	37.7	36	16.7	36	6.0	Aug. 1-31	.....	80.3	......	3.11	......	8
Palestine	Aug. 10-Sept. 4	2,891	1,858	366	19.7	12.9	3.0	3.8	751	26.1	614	5.7	334	1.8	Aug. 1-31	89.4	80.5	+0.1	1.43	−1.25	11
Roosevelt	Sept. 24	350	224	58	25.9	7.1	13.8	5.0	109	13.0	42	4.8	29	0.0	Sept. 1-30	90.9	79.0	+3.5	4.10	......	7
San Antonio	Aug. 15	401	35	25	71.4	0.0	71.4	0.0	8	0.0	0	0.0	2	0.0	Aug. 1-31	91.9	82.0	−0.2	2.25	−1.59	9
Taylor	Aug. 16	797	306	50	16.3	11.8	1.3	3.3	170	21.0	82	2.4	31	0.0	Aug. 1-31	90.4	80.9	......	2.08	......	5
Terrell	Sept. 19	308	99	4	4.0	1.0	3.0	0.0	57	1.8	30	0.0	6	0.0	Sept. 1-30	89.2	77.9	......	3.96	......	6
Trinity	Aug. 9-30	8,637	2,966	1,499	50.5	10.4	37.7	2.4	1,011	25.7	292	11.3	295	5.1	Aug. 1-31	89.3	81.4	−1.4	1.79	−1.67	4
Victoria	June 16-Sept. 1	11,828	7,772	4,522	58.1	26.4	28.1	3.7	3,368	57.8	699	10.6	652	3.2	June 1-Sept. 30	91.2	82.1	−0.4	13.20	+0.45	28
Waco	July 25-Oct. 12	10,809	3,534	2,207	62.5	25.4	26.4	10.7	1,072	64.7	396	26.5	809	12.1	July 1-Sept. 30	92.	82.2	−0.7	15.99	+9.01	15
Total	....	86,956	38,991	20,285	52.0	20.7	27.0	4.3	12,568	52.6	5,663	18.0	6,773	6.3	....	.....	.....	.....	.....	.....	....

[a] Includes each stage found alive or dead from effects of heat or drying, and also counts one for each weevil cell emptied by ants and for each instance of parasite occurrence.

[b] Weevil stages destroyed by ants could not be easily determined. Those destroyed by parasites could have been determined, but were not.

[c] In cases where weather records are not kept for the locality where examinations were made, the records from the nearest weather station having similar climatic conditions have been used.

Ants (*Solenopsis geminata*) accomplish a greater destruction of weevil stages than heat and parasites combined. Parasites are decidedly the least important of the three factors.

So many conditions influence the effect of sunshine especially that it is difficult to determine whether there exists anything like a constant relationship between the maximum temperatures at a locality and the mortality from heat or drying. In some cases a relationship is evident which can not be regarded as merely accidental. The localities in which a comparatively small series of examinations was made should not be considered in this connection.

The highest proportion of rainy days occurred at Calvert during July and August, being twenty-five in sixty-one days. The influence of each factor of natural control seems to have been greatly reduced by the excessive amount of rain (10.22 inches) distributed over so many days. The total mortality was but 15.1 per cent, distributed among the factors as follows: Heat 3.9 per cent, ants 9.3 per cent, parasites 2.1 per cent. The high maximum temperatures occurring were evidently prevented from exerting their usual influence by the almost continuously wet condition of the ground. This produced a high percentage of relative humidity which would naturally favor the development of the weevils.

Fortunately for this portion of our study an automatic self-registering combined thermograph and hydrograph had been located at Calvert early in the season of 1906, and the records from this machine furnish valuable data regarding humidity conditions which could not otherwise be obtained. These records may be used in connection with Weather Bureau reports for the locality of Calvert and some interesting facts will appear.

Around Calvert very light rains fell early in June, but from that time until June 25 there was no rainfall. The period from June 5 to June 25, 1906, shows an average relative humidity[a] amounting to about 69 per cent. From June 25 till after September 10 showers were of frequent occurrence and the records show during this period an average relative humidity of 75 per cent. Doubtless very significant facts might be learned if for other localities data similar to those obtained for Calvert were available for comparison.

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[a] Relative humidity is the term used to denote the proportion of atmospheric moisture which actually exists as compared with the amount of moisture which it would be possible for the air to contain at any given temperature. If the air contains all the moisture possible, it is said to be "saturated" and this is the condition during fogs and sometimes, though not always, during rains. It is the condition of the air at a given point when dew is deposited. The relative humidity under this saturated condition is 100 per cent. The condition opposite to this extreme is a perfectly dry air in which the relative humidity is 0. The amount of moisture, or water vapor, which it is possible for a given amount of air to contain is much greater if the air be warm than if it be cold. Thus, taking a certain quantity of air containing a definite quantity of water vapor, the percentage of relative humidity will increase as the temperature is lowered and decrease as the temperature is raised. A low percentage of relative humidity naturally promotes evaporation owing to absorption of the moisture by the drier air, while evaporation ceases, even from a water surface, when the air becomes saturated. During the summer in central Texas the relative humidity increases at a few feet above the ground during the nights until it reaches, as a rule, a maximum of between 90 and 95 per cent. During the day it decreases until in the warmest part of the afternoon it reaches a minimum of between 30 and 50 per cent.

INFLUENCE OF CLIMATIC CONDITIONS ESPECIALLY.

In further determining whether climatic conditions were the most important factors affecting the total mortality percentages, conclusions may be more readily drawn by arranging the data in three groups, ranging from the highest total mortality to the lowest. Group A may include the eleven localities having a total mortality above the average of 52 per cent, ranging from 84 to 52.5 per cent. Group B may include seven localities having a total mortality ranging from 51.4 to 39.4 per cent. The division between Group B and Group C is made because of the rather large difference in percentage of total mortality shown between 39.4 per cent, the lowest in Group B, and 28 per cent, the highest in Group C. Group C includes ten localities with the total mortality percentage ranging from 28 per cent to zero. Each group is summarized to facilitate a general comparison of the average results of the observations made and of the average climatic conditions prevailing. The data are presented in Table VII.

TABLE VII.—*Comparison of mortality records, with localities arranged in percentage groups.*

GROUP A.—ELEVEN LOCALITIES HAVING ABOVE 52 PER CENT OF TOTAL MORTALITY.

Locality.	Date or period.	Total of four classes of forms examined.	Total weevil stages found.	Total stages killed by heat, ants, and parasites.	Total mortality from three causes.	Percentage of mortality from—			Mortality from heat or drying, by stages.						Climatic condition.						
									Larva.		Pupa.		Adult.			Temperature F°.			Rainfall.		
						Heat or drying.	Ants.	Parasites.	Number of stages found.	Per cent of stages dead.	Number of stages found.	Per cent of stages dead.	Number of stages found.	Per cent of stages dead.	Period included.	Mean maximum.	Mean average.	Departure from normal.	Total precipitation.	Departure from normal.	Number of rainy days.
	1906.				*P. ct.*										1906.				*Ins.*	*Ins.*	
Beeville, Tex	July 12–Oct. 1	5,428	2,968	2,484	84.0	20.0	62.8	1.2	640	75.3	181	43.1	170	12.9	July 1–Aug. 31	94.2	83.8	−1.35	5.49	+1.42	12
Overton, Tex	Aug. 23	953	422	310	73.5	6.5	64.1	1.6	64	37.7	36	16.7	36	6.0	Aug. 1–31	.....	80.3	.....	3.11	.....	8
San Antonio, Tex	Aug. 15	401	35	25	71.4	0.0	71.4	0.0	8	0.0	0	0.0	2	0.0	....do	91.9	82.0	−0.2	2.25	−1.59	9
Corpus Christi, Tex	July 10	1,039	458	322	70.3	40.0	27.1	3.5	183	88.0	45	37.7	43	2.3	July 1–31	88.8	83.0	+1.3	0.41	−0.91	3
Hallettsville, Tex	Aug. 9–31	4,124	1,805	1,272	70.0	31.7	35.8	3.0	571	80.0	220	41.4	268	10.0	Aug. 1–31	95.0	84.6	+1.1	0.85	−1.54	3
Cuero, Tex	Aug. 9–31	3,039	1,766	1,219	69.0	39.5	23.9	5.7	773	72.3	238	50.9	135	12.6	....do	94.5	83.8	−1.0	2.43	+0.77	4
Waco, Tex	July 25–Oct. 12	10,809	3,534	2,207	62.6	24.1	26.4	10.7	1,072	64.7	296	26.5	809	12.1	July 1–Sept. 30	92.2	82.2	−0.7	15.99	+9.01	15
Junction, Tex	Sept. 24	427	146	90	61.6	27.4	25.4	8.2	52	19.2	13	9.2	28	8.9	Sept. 1–30	90.9	79.0	+3.6	4.44	+2.80	7
Victoria, Tex	June 16–Sept. 1	11,828	7,772	4,522	58.1	26.4	28.1	3.7	3,368	57.8	699	10.6	652	3.2	June 1–Sept. 30	91.2	82.1	−0.4	13.20	+0.45	28
Mansfield, La	Aug. 24–Sept. 29	4,324	1,562	872	56.1	13.6	39.2	3.2	234	50.1	152	36.2	453	8.6	Aug. 1–Sept. 30	89.7	78.9	+1.5	7.37	.....	16
Brownsville, Tex	July 28–Sept. 5	8,962	3,479	1,822	52.5	34.8	11.6	6.0	1,181	85.3	629	23.7	993	5.7	July 1–Aug. 31	92.2	84.1	+0.9	8.83	+3.88	12
Totals and average percentages: Eleven localities		52,334	23,947	15,145	63.2	27.0	31.5	4.8	8,146	67.4	2,609	26.6	3,589	8.0	Nineteen month-periods.	91.9	82.2	+0.17	3.39	+0.89	6.2

GROUP B.—SEVEN LOCALITIES HAVING BELOW 52 PER CENT OF TOTAL MORTALITY.

Locality.	Date or period.	Total of four classes of forms examined.	Total weevil stages found.	Total stages killed by heat, ants, and parasites.	Total mortality from three causes.	Heat or drying.	Ants.	Parasites.	Larva: Number of stages found.	Larva: Per cent of stages dead.	Pupa: Number of stages found.	Pupa: Per cent of stages dead.	Adult: Number of stages found.	Adult: Per cent of stages dead.	Period included.	Mean maximum.	Mean average.	Departure from normal.	Total precipitation.	Departure from normal.	Number of rainy days.
Mineola, Tex	Aug. 10–Oct. 2	1,075	502	258	51.4	31.5	17.9	2.0	215	36.4	138	48.0	49	28.4	.....	.....	.....	.....	.....	.....	.....
Trinity, Tex	Aug. 9–30	8,637	2,966	1,499	50.5	10.4	37.7	2.4	1,011	25.7	292	11.3	295	5.1	Aug. 1–31	89.3	81.4	−1.4	1.79	−1.67	4
Goliad, Tex	Aug. 7–Sept. 3	2,660	1,428	661	46.3	19.3	19.0	8.5	407	46.7	256	30.0	334	3.0	....do	90.2	81.6	−0.9	4.52	+2.14	6
Corsicana, Tex	Aug. 23–Sept. 18	1,711	311	126	40.5	19.3	14.8	4.5	80	55.0	61	18.2	98	5.1	Sept. 1–30	90.9	79.7	+1.6	2.53	−0.71	7
Many, La	Aug. 23	5,180	2,828	1,138	40.2	11.0	26.9	4.0	420	40.0	484	14.0	946	7.0	Aug. 1–31	92.9	80.6	.....	0.58	−2.79	2
Marshall, Tex	Aug. 22	452	93	37	40.0	17.2	16.1	7.5	40	32.5	17	11.8	15	6.7	....do	88.7	79.3	.....	2.65	.....	7

Orangeville, La.	Aug. 23-Sept. 10	1,195	502	196	39.4	2.6	35.5	1.0	109	6.4	83	4.8	105	2.0	Aug. 1-Sept. 30	89.4	80.2	+2.0	6.01	−1.31	9
Totals and average percentages: Seven localities		19,910	8,630	3,915	45.4	13.0	26.0	3.8	2,282	33.0	1,331	19.3	1,852	6.0	Seven month-periods.	90.1	80.4	+0.56	2.6	−0.72	5

GROUP C.—TEN LOCALITIES HAVING BELOW 28 PER CENT OF TOTAL MORTALITY.

Dallas, Tex.	Aug. 29-Oct. 15	5,307	1,596	446	28.0	5.5	17.7	4.7	272	21.3	285	3.8	567	3.2	Aug. 1-31	90.8	80.0	−3.2	4.25	+2.38	8
Roosevelt, Tex.	Sept. 24	350	224	58	25.9	7.1	13.8	5.0	109	13.0	42	4.8	29	0.0	Sept. 1-30	90.9	79.0	+3.5	4.10	......	7
Palestine, Tex.	Aug. 10-Sept. 14	2,891	1,858	366	19.7	12.9	3.0	3.8	751	26.1	614	5.7	334	1.8	Aug. 1-31	89.4	80.5	+0.1	1.43	−1.25	11
Taylor, Tex.	Aug. 16	797	306	50	16.3	11.8	1.3	3.3	170	21.0	82	2.4	31	0.0	do	90.4	80.9	......	2.08	......	5
Calvert, Tex.	Aug. 22-Sept. 13	3,407	1,646	253	15.1	3.9	9.3	2.1	363	13.5	515	2.5	315	0.6	Aug. 1-Sept. 30	94.6	83.7	+1.5	10.22	+6.10	2.5
Lula, Tex.	Sept. 26	324	105	12	11.4	2.0	10.0	0.0	50	4.0	23	0.0	10	0.0	......	......	......	......	......	......	....
Kerrville, Tex.	Aug. 25-Sept. 3	546	330	34	10.3	3.0	4.0	3.3	239	4.2	51	0.0	12	0.0	Aug. 1-31	95.3	82.4	+1.2	3.47	+1.90	9
Terrell, Tex.	Sept. 19	308	99	4	4.0	1.0	3.0	0.0	57	1.8	30	0.0	6	0.0	Sept. 1-30	89.2	77.9	......	3.96	......	6
Johnsons Bayou, La.	Aug. 22-27	300	225	2	0.9	0.4	0.4	0.0	106	0.0	81	1.2	36	0.0	......	......	......	......	......	......	....
Fullers, Tex.	Aug. 17	482	25	0	0.0	0.0	0.0	0.0	23	0.0	0	0.0	2	0.0	Aug. 1-31	90.8	80.0	−3.2	4.25	+2.38	8
Totals and average percentages: Ten localities		14,712	6,414	1,225	19.1	7.1	8.7	3.3	2,140	17.1	1,723	3.7	1,342	2.0	Nine month-periods.	91.8	80.9	+0.01	3.75	+1.92	8.80
Summary of all sections below 52 per cent.		34,622	15,044	5,140	34.2	10.5	18.6	3.6	4,422	25.4	3,054	10.5	3,194	4.3	Sixteen month-periods.	91.9	80.7	+0.4	3.24	+0.6	7.1

TOTALS FOR EACH GROUP OF LOCALITIES.

Seven localities, Group B	19,910	8,630	3,915	45.4	13.0	26.0	3.8	2,282	33.0	1,331	19.3	1,852	6.0	Seven month-periods.	90.1	80.4	+0.56	2.6	−0.73	5.0
Ten localities, Group C	14,712	6,414	1,225	19.0	7.1	8.7	3.3	2,140	17.1	1,723	3.7	1,342	2.0	Nine month-periods.	91.8	80.9	+0.01	3.75	+1.92	8.8
Seventeen localities, Groups B and C	34,622	15,044	5,140	34.2	10.5	18.6	3.6	4,422	25.4	3,054	10.5	3,194	4.3	Sixteen month-periods.	91.9	80.7	+0.4	3.24	+0.60	7.1
Eleven localities, Group A	52,334	23,947	15,145	63.2	27.0	31.5	4.8	8,146	67.4	2,609	26.6	3,589	8.0	Nineteen month-periods.	91.9	82.2	+0.17	3.39	+0.89	6.2

From the eleven localities in Group A 52,334 forms were examined. This number constitutes 60.2 per cent of the total of the three groups. In these forms were found 23,947 weevil stages. This number constitutes 61.4 per cent of the total number of weevil stages found in the three groups. The proportion of weevil stages to forms examined in each of the groups varies but slightly. When we come to the total number of weevil stages killed by the three factors, we find in Group A 15,145 dead, which number is 74.7 per cent of the total mortality occurring in the three groups. This shows that in Group A there was actually an increase of nearly 15 per cent in the total mortality above the average proportion which might have been expected in this group. The average mortality occurring in Group A is 63.2 per cent. The percentage of mortality in Group A from each of the three factors is somewhat greater than the average shown in Table VI. For heat and drying this increase amounts to 6.3 per cent, for ants to 4.5 per cent, for parasites to 0.5 per cent. The greatest increase is therefore attributable to heat or drying and it might naturally be expected that the climatic records would show a considerably higher maximum temperature to account for this increased mortality. A comparison of the mean maximum temperature records for Group A with those for Groups B and C shows, however, an average difference of less than 2 degrees. Between A and C there is an average difference of but 0.1 degree. In group A 27 per cent of the weevil stages found were destroyed by heat or drying, while in Group C, having almost identically the same mean maximum temperature, the mortality from this cause is but 7.1 per cent—a decrease in Group C of 19.9 per cent.

The percentage of mortality from ants shows an even greater difference between Groups A and C than has just been shown for heat, amounting in this case to a decrease of 22.8 per cent. Certainly this difference can not be attributed to the variations in temperature shown for these groups.

While unquestionably an unusual deficiency of rainfall is very important in checking the development of weevils, the difference shown in this table for the average monthly rainfall in each of the three sections can not account for the difference found in the total mortality from any of the three factors. Thus in Group A, having a monthly average of 3.39 inches, which is 0.89 of an inch above the average normal rainfall for the localities given, and an average of 6.2 rainy days per month, the mortality from heat or drying averages 27 per cent. In Group B, for seven localities the average total rainfall is 2.6 inches per month. For these localities this is a deficiency amounting to 0.72 inches per month. We have here five rainy days per month and the mortality from heat or drying is but 13 per cent, or less than one-half the mortality found in Group A. Similarly, in Group C, with a mean maximum temperature approximately the same as that in Group A and a total rainfall for each month averaging 3.75 inches, which is 1.92 above the normal, there is a total mortality from all three causes averaging but 19.1 per cent, while that from heat alone averages but 7.1 per cent. A comparison of the mortality from ant work between Groups A and C shows in C a decrease which is very nearly proportional to that found for heat, while the reduction in parasite work is comparatively slight.

These facts seem to point to the conclusion that other factors than climatic conditions must explain the variations in mortality which are shown in this table. Undoubtedly *extreme* variations in temperature and rainfall are exceedingly important, but it is obvious that the *average* variation in these factors does not produce a corresponding variation in the mortality figures, such as might be expected. Evidently there are other factors modifying or neutralizing the effect of climatic variations, which if acting alone might produce more consistent results.

INFLUENCE OF CULTURAL CONDITIONS.

High temperature can affect the weevil stages only after the forms have fallen or been so cut off from vital connection with the plant that the sap flow is stopped and a drying of the form results. The effect upon the weevil stage will then depend upon the conditions of exposure to the heat. If the square or boll remains hanging or dries upon the plant, the temperature in it will not rise as high as if those forms were exposed directly to sunshine upon the surface of the ground. If the square or boll falls to the ground, its position in regard to the shade of the plant will determine largely the degree of exposure to the heat of the sun and, consequently, the probability as to the survival or destruction of an inclosed weevil stage. The direction in which the rows run, and more especially the open distance between plants, will affect the exposure of the fallen forms to the direct action of the sun. The dryness of the surface soil is another factor which will largely affect the drying of the forms and the mortality resulting from heat. The work of the living larvæ naturally produces a larger degree of moisture in the infested forms than will be found in those which contain no weevil stage. If the conditions are such as to insure a very rapid and complete drying of the form within a few days after it falls to the ground, there is a strong probability that the weevil stages affected will be destroyed by heat or drying. If climatic or environmental conditions favor the weevil's development until the pupal stage is reached, the condition of the form is then much more favorable for the entrance and attack of the ants. The ants seem to be able to recognize the presence of a living weevil stage within a form and rarely, if ever, enter forms in which the stages have previously been destroyed by heat. If ants destroyed both parasite and weevil stages no evidence of the parasitism might remain. It is possible that the indiscriminate work of ants may explain, in part at least, the fact that fallen forms have invariably yielded a smaller percentage of parasites than have hanging forms. Referring to Table III, this difference in the percentage of parasite attack is shown as follows: In hanging bolls, 6 per cent; in hanging squares, 12.8 per cent; in fallen bolls, 1 per cent; in fallen squares, 3.2 per cent. As the ants are already distributed in the cotton fields throughout the weevil-infested area, it is evident that their relative abundance in different localities may explain to a considerable extent the variations which have been found in the percentage of mortality resulting from ant attack.

It has been found that all of the parasites which attack the weevil are native species having some other host which lives normally in some part of the vegetation surrounding the cotton fields. In no case can the weevil be considered as the primary or preferred host of any of these species. It has been found that in many instances the occurrence of other weevils, living under such diverse conditions as in the buds, flowers, fruit, seeds, stems, roots, or in galls formed by the attack of some other insect, a large variety of weeds, or other common plants and of trees, directly influences the abundance of parasite species and explains variations which have been found in the extent of parasite attack upon the boll weevil. It is plain, then, that the abundant occurrence of some plant supporting a large number of other weevils which do not at all affect cotton may produce indirectly an abundance of some parasite species which is capable of attacking the weevil. It is to be hoped that some of these parasites may ultimately develop a preference for the boll weevil as their host. This would seem to be a possibility, because the boll weevil presents a continuous series of stages for parasite attack throughout the season, whereas in many cases it is known that parasites are forced by the short breeding season of their original host to change from one host to another in order to continue their own reproduction throughout the season. The tendency of parasites to adapt themselves to this change in possible host conditions demands continued careful investigation.

The note records concerning cultural conditions in the various fields investigated are not as complete as is desirable for this study, but a general summary of conditions as noted will be given to determine the possibility that cultural conditions may explain some of the variations which have been found in mortality. In Table VIII, Group A, the cultural notes are given for most localities recorded in Table VII, Group A. The same arrangement in regard to total mortality is retained.

TABLE VIII.—*Comparison of cultural and other conditions, with localities arranged as in Table VII.*

GROUP A.

Locality.	Total mortality.	Date of cultural notes.	Nature of soil.	Direction of rows.	Spacing of plants.	Condition of cultivation.	Remarks.
	Per cent.	1906.					
Beeville, Tex	84.0	July 12	Black; sandy	N.-S.	Where stand, one-half shade.		Blooming freely many dried fallen squares. Inf. 84 per cent 1,000 square lot.
Beeville, Tex	84.0	Aug. 8–Sept. 3	Black; sandy	E.-W.	Rows 4 feet		Well budded; squares down to middle of plants.
Overton, Tex	73.5	Aug. 23	Sandy upland		3 by 1½	Fair	Cotton grown in clearings in pine forest. Plants small.
San Antonio, Tex	71.4						
Corpus Christi, Tex	70.3	July 10	Black; sandy	NNW.-SSE	Even stand; ground two-fifths shade.	Well tilled	Cotton opening. Ground very dry and cracked.
Hallettsville, Tex	70.0	Aug. 31	Post-oak	2 fields; N.-S.	3 by 1½		Cotton opening. Dead in many places; green in patches.
Cuero, Tex	69.0	Aug. 31	Black	NW.-SE	3½ by 1½		Picked over once. Squares scarce. Many bolls.
Waco, Tex	69.0	Aug. 28	Loose gray		3½ by 1¼		Davis field: Stalk medium, foliage not dense. Solenopsis numerous. Weaver field: Part of examination in rank, part in small cotton. Ants not abundant.
	69.0	Aug. 29	Mixed				
Junction, Tex	61.6	Sept. 24	Medium brown; sandy.	N.-S.	3 by 1½	Rank cotton and weeds.	Wet season. Irrigated field: alternate corn and cotton.
Victoria, Tex	58.1	June 22	Black bottom	NE.-SW.	Stand poor, 3½ by 1½	Not well cultivated	½ acre. Very dry May and June. Solenopsis fairly abundant.
	58.1	July 1	Black bottom	E.-W.	½ shaded, 4 by 1½	Well cultivated	Plant breeding plat. Plants large, Guadaloup bottom.
	58.1	July 18	Black bottom	E.-W.	4 by 1½	Fairly cultivated	
Mansfield, La	56.1	Aug. 24	Sandy; rolling	E.-W.	4 by 1½		A fair field. Plants defoliated by rust. King, early planted. Solenopsis very numerous.
Brownsville, Tex	52.5	July 28	Black loam				Dorsett field. Planted Feb. 1. Fallen squares.
	52.5	Sept. 5	Black mesquite		Dying in places		Many fallen squares. Picked over once. Some leaf-worm work.

TABLE VIII.—*Comparison of cultural and other conditions, with localities arranged as in Table VII*—Continued.

GROUP B.

Locality.	Total mortality.	Date of cultural notes.	Nature of soil.	Direction of rows.	Spacing of plants.	Condition of cultivation.	Remarks.
	Per cent.	1906.					
Mineola, Tex	51.4	Aug. 10	Deep sand	E.-W	3½ by 1½	Good	Plants large. Fertilized. Very dry and hot.
Trinity, Tex	50.5	Aug. 9	Sandy	E.-W	4 by 1		Large part of leaves fallen from rust. Many Solenopsis seen. Much rain for past five weeks.
Trinity, Tex	50.5	Aug. 30	Black, almost wax	N.-S.	4 by 1½		Plants shade only portion of ground. Fair number Solenopsis.
Goliad, Tex	46.3	Aug. 7	Black loam	N.-S	4½ by 1½		
Corsicana, Tex	40.5	Aug. 23	Sandy	N.-S	4 by 1½		
Many, La	40.2	Aug. 23	Sandy with humus				Fair number Solenopsis.
Marshall, Tex	40.0	Aug. 22	Sandy upland		3 by 1½	Good	Cotton grown in clearings in pine forest.
Orangeville, La	39.4	Sept. 30	Deep sandy	N. E.-S. W	3 by 1½	Fair	Few squares present. Nearly defoliated by leaf worm. Plants fair size.
GROUP C.							
Dallas, Tex	28.0	Oct. 1	Black prairie	N.-S	4 by 1½	Fairly good	Solenopsis quite numerous. Considerable root rot, causing dead areas.
Roosevelt, Tex	25.9	Sept. 24	Dark sandy loam	E.-W	3 by 1½		Plants average 4½ feet high.
Palestine, Tex	19.7	Aug. 10	Sandy hillside	N.-S	3½ by 1¼		Solenopsis apparently not abundant. Heavy foliage; ground partially shaded.
Taylor, Tex	16.3						No record.
Calvert, Tex	15.1	Sept. 1	Black bottom	NE.-SW	4 by 1½	Good	Cotton rank; ground shaded.
Lula, Tex	11.4	Sept. 26	Dark sandy loam		3 by 1⅓		Plants about 3½ feet high.
Kerrville, Tex	10.3	Aug. 25	Dark sandy loam	N.-S	3 by 1¼		Plants about 3 feet high.
Terrell, Tex	4.0						No record.
Johnsons Bayou, La.	0.9						Do.
Fullers, Tex	0.0						Do.

From a careful study of Table VIII it is quite evident that no single cultural factor will be found to explain the varying mortality. The character of the soil in each group varies from sandy postoak to black river bottom. The direction of the rows fails to show any consistent relationship to the proportion of weevil stages destroyed. The condition of cultivation was recorded for but few fields, and may practically be disregarded because of the lack of data. In the column for spacing of plants among the remarks are some points which were undoubtedly influential in producing the mortality results shown. Table VIII should be studied in connection with Table VII. At Beeville it was noted that the stand was poor and that only one-half of the ground was shaded where the stand was good. A large proportion of the squares were infested as early as July 12, and fallen, drying squares were abundant on the ground. Referring to Table VII in connection with Table VIII, it will be seen that under these conditions, with only fallen squares and bolls examined, the mortality from heat was quite large, but that caused by ants was relatively more than three times as great. Had the ants not been so active, it is very likely that the percentage of mortality from heat would have been very much greater. As it was, so many weevil stages were destroyed by the ants soon after the forms had fallen that the mortality from heat was kept comparatively low.

At Beeville about the middle of July the cultural notes indicate that the stand was uneven and that at best only about one-half of the ground was shaded. During July and August the climatic records show that the temperature averaged 1.5 degrees below normal, while the rainfall amounted to 1.42 inches above normal. Doubtless the excess of rainfall and the deficiency of heat are correlated. Under these conditions, however, there occurs the highest total mortality found in any locality, i. e., 84 per cent. Of this total mortality heat and drying was responsible for 20 per cent, while ants destroyed 62.8 per cent. In this case, therefore, it is evident that the ants were far the most important factor in producing the highest recorded percentage in mortality, and it would appear that their work was favored by the conditions of open spacing, medium heat, and much moisture.

At Overton the ants caused an even greater proportion of the total mortality than is shown above for Beeville. At San Antonio the examinations were not extensive, but the ants were responsible for the entire mortality found. In these three cases of highest total mortality the climatic factors would seem to have been much less important than was the abundance of the ants, which might have been influenced by local conditions.

At Corpus Christi all of the examinations were made on July 10. The notes show that at that time the ground was about two-fifths shaded, while it was very dry and had cracked deeply. The temperature records at Corpus Christi (Table VII) show far less range in temperature than is found at most of the other localities, which are all situated farther from the coast. The mean maximum temperature, therefore, appears to be relatively low, although the mean average temperature is 1.3 degrees above the normal for that locality. The weather records for May show that the temperature averages 1.3 degrees above normal, while during that month the rainfall was 1.78 inches below normal. June records show that the temperature averaged 1.7 degrèes above normal, while rainfall was 1.63 inches below normal. July was also warm and dry, so that in this case the 40 per cent of mortality ascribed to heat or drying is very evidently the result of the extreme drought which had prevailed during the preceding eight or ten weeks. The high total mortality at Corpus Christi appears, therefore, to be largely a direct result of the extreme drought in a very open field, together with the active assistance of the ants.

At Hallettsville during August occurred the highest mean maximum temperatures found in any locality except Kerrville, although the mean average temperature was only 1.1 degrees above normal. The rainfall recorded was 1.54 inches below normal for the month. The full effect of this drought was probably not realized because of the fact that during the month there were traces of rain upon eleven days, when the precipitation was not sufficient to be measured. The cotton was dying in places and green in patches, so that forms must have been largely exposed, and the high temperature and drought should have produced an even higher mortality than the 31.7 per cent found for this factor. The effect is probably also modified by the fact that during July nearly the normal amount of rain had fallen, so that the ground during August was not nearly as dry as it was at Corpus Christi during July. At Hallettsville, also, ants were responsible for more than the average percentage of mortality. An explanation of the reasons for the great difference shown in the effect of heat, especially between Hallettsville and Kerrville, may be given at this point. A direct comparison of the Weather Bureau records will show at a glance how the influence of one important factor may be essentially affected by other related factors, and in this case it will afford an ample explanation of the mortality from heat, amounting to 31.7 per cent at Hallettsville, with a mean maximum temperature of 95 degrees, and only 3 per cent at Kerrville, with a similar temperature of 95.3 degrees.

Table IX.—*Explanation of variation in temperature effects at Hallettsville and Kerrville, Tex.*

Locality.	Temperature conditions.						Rainfall and cloud conditions.					
	Absolute maximum.		Average.		Mean average for month.	Departure from normal.	Rainfall.			Cloudiness.		
	Degrees Fahrenheit.	Number of days occurring.	Maximum.	Minimum.			Total.	Departure from normal.	Number of rainy days.	Number of days cloudy.	Number of days partly cloudy.	Number of days clear.
			°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*Inches.*				
Hallettsville	99	5	95.0	74.1	84.6	+1.1	0.85	−1.54	3	6	11	14
Kerrville	98	2	95.3	69.5	82.4	+1.2	3.47	+1.90	9	14	13	4

Such differences as those shown in rainfall and cloud conditions are entirely sufficient to explain the difference in the effectiveness of similar maximum temperatures.

At Cuero the month of June was extremely hot and dry, showing a temperature averaging 4.6 degrees above normal and rainfall 2.04 inches below normal. These conditions are probably responsible for the major portion of the crop that was set in that locality. During July there was an excess of rainfall amounting to 2.63 inches, while during August the excess amounted to 0.77 inch. While the mean average temperature for August was 1 degree below normal, the mean maximum temperature ranged very high. In this case it appears that the mortality from heat or drying, amounting to 29.5 per cent, was due not so much to drought as to the fact that the maximum temperature experienced during the month reached 95 degrees or higher upon nineteen days. In this case, apparently, heat may have been the important factor rather than drying.

At Waco, Junction, and Victoria, Tex., the mortality is very evenly divided between heat and ants, the excess at Waco being due to a much larger percentage of parasitism. At Brownsville a large proportion of the mortality appears to have been due to heat, and this would seem to be a natural condition for that locality.

The study of the data shown in Tables VII and VIII for the localities in Group B indicates similar conclusions for those shown for Group A. At Mineola, in a total mortality of 51.4, 31.5 per cent was due to heat or drying, and the remarks state that it was "very dry and hot" at the time the collection was made.

At Trinity, with 50.5 per cent mortality, but 10.4 per cent was due to heat, while the destruction of stages by ants amounted to 37.7 per cent. The remarks show that although a large portion of the leaves had fallen from the plants because of a fungous disease, the excessive amount of rainfall would naturally prevent a large mortality from heat or drying, while the presence of "many Solenopsis" directly explains the large proportion of the total mortality which was due to their work. During July the rainfall amounted to 8.36 inches, amply justifying the remark, "Much rain for past five weeks," and fully explaining the low mortality from heat or drying.

The remaining localities given in Group B and those which have been included in Group C show a continual decrease in total mortality. The decrease is more evident from the effects of heat or drying and from ant attack than it is from the attack of parasites. Thus in Group B the average weighted percentage of mortality from the parasite attack is 3.8, while in Group C it is 3.3 per cent. From ant work in Group B there is a weighted average mortality of 26 per cent, while in Group C it averages 8.7. Mortality from heat or drying in Group B is 13 per cent, while in Group C it is but 7.3 per cent. It is evident that the extent of ant and parasite attack will be directly influenced more by the abundance of the species concerned than by the climatic conditions under which they may work. It is impossible to determine whether ants or parasites are particularly abundant in any locality except by determining the proportion of weevil stages which they have destroyed, but the primary actual cause of their abundance may depend upon very different conditions.

It is possible that the ants might be quite abundant and still attack the weevil stages but little if some other food supply were more easily available. It is manifestly more difficult to determine why mortality is low in a field than it is to determine what are the effective factors when it is high. From a comparison of Groups A and C in Table VIII it would appear that in Group A the predominant type of soil is sandy, while in Group C the soil is heavier and probably would tend to give a ranker growth of weed. This conclusion seems to be borne out by the remarks given for Group C, which indicate a heavy growth and a large degree of shade. This condition would decrease the efficiency of sunshine, and it is quite likely also that the soil conditions in these fields were not as favorable to the ants as in the more sandy locations.

It has been generally considered that the weevil has done greater damage in river bottoms than in upland fields. This has been held to be due to the greater moisture of the bottom lands and the ranker growth of the plants grown thereon. From the considerations which have been mentioned it would appear that this idea is well founded, but that the difference is due in a possibly equal degree to the absence of ants in the river bottoms. If this be true, then the importance of strictly cultural methods in controlling the weevils in the bottom lands may be even greater than it is on uplands, since as a general rule the factors of natural control may be less effective in such locations. It is evident, however, that there is no definite line of division between the localities in which natural control will be most effective and those in which it will be least so. Only by continuing observations for several years will it be possible to determine at all definitely the class of locations which will benefit most largely by the average effectiveness of these factors of natural control.

INFLUENCE OF PERIOD OF INFESTATION UPON NATURAL CONTROL.

A rearrangement of the data given in Tables III and V may be used to give a comparison of the results according to the classes of forms examined for Louisiana and for Texas. The separation of the data for the two States is made to enable a comparison as to mortality in a recently infested area, as in Louisiana, with an area which has been infested for a considerable time, as is the case with nearly all the localities examined in Texas.

TABLE X.—*Summary of results showing mortality in Louisiana and Texas resulting from heat or drying, ants, and parasites.*

State and class of fruit.	Total number of forms examined.	Total number of weevil stages found.	Total number of weevil stages dead.	Total mortality by three causes.	Weevil stages killed.					
					Heat or drying.		Ants.		Parasites.	
					Number.	Per cent of total stages.	Number.	Per cent of total stages.	Number.	Per cent of total stages.
Louisiana:				*Per ct.*						
Hanging bolls	2,955	1,163	458	39.4	137	11.8	252	21.7	69	6.0
Hanging squares	1,268	847	519	61.3	175	20.7	274	32.3	70	8.3
Fallen bolls	2,606	599	200	33.4	54	9.0	141	23.5	5	0.8
Fallen squares	4,170	2,508	1,031	41.1	160	6.4	859	35.7	12	0.7
Total, Louisiana	10,999	5,117	2,208	43.2	526	10.3	1,526	29.8	156	3.0
Texas:										
Hanging bolls	14,404	4,270	1,192	27.0	289	6.8	650	15.2	253	6.0
Hanging squares	5,736	3,383	1,708	50.5	629	18.6	609	18.2	470	13.9
Fallen bolls	20,079	4,019	1,323	32.9	473	11.8	810	20.2	40	1.0
Fallen squares	35,738	22,202	13,854	62.7	6,141	27.8	6,947	31.3	770	3.5
Total, Texas	75,957	33,874	18,077	53.5	7,532	22.3	9,016	26.7	1,533	4.6
Total, Louisiana and Texas	86,956	38,991	20,285	52.0	8,058	20.7	10,542	27.1	1,689	4.3

Naturally the examinations in Texas cover a much larger number of forms than do those in Louisiana, amounting to 87.4 per cent of the total for the two States. The Louisiana forms show a slightly greater proportion of weevil stages to forms examined than do those from Texas, in the former case the proportion being one weevil stage to each 2.15 forms, in the latter State one weevil stage per 2.25 forms. This difference is, of course, but slight.

In comparing the mortality results for the two States it appears that in Texas the total mortality averaged fully 10 per cent higher than it did in Louisiana. The smaller mortality found in Louisiana, being inevitably connected with a higher proportion of weevil development, doubtless explains sufficiently the slightly higher proportion of weevil stages to forms examined which was found in that State. A comparison of the mortality from each of the three factors shows that in Texas the mortality from heat or drying and from parasites exceeds that from these causes in Louisiana, while in the latter State the proportion of mortality due to the work of ants is slightly greater than that found in Texas. Nearly all of the excess in total mortality found in Texas is shown to be due to heat or drying. A sufficient explanation for this difference in the effect of heat in the two States is not brought out by the notes. By reference to Table VII it may be seen that only one locality in Louisiana (Mansfield) is to be found in Group A, which contains those localities having a total mortality greater than 52 per cent. In that case it is quite evident that ants were responsible for about three-fourths of the total mortality found. It is also evident that the mortality from heat in that locality was greater than at any other locality examined in Louisiana. This was doubtless due to the early defoliation of the plants by rust, but even in this case it was hardly equal to one-half of the average mortality from heat found in Group A. In Table VIII it is shown that all of the fields examined in Louisiana had a sandy soil. This soil condition may have been related in some way to the larger mortality from ant work and to the smaller mortality from heat or drying, but further observations are needed to definitely determine the correctness of this supposition. It is noticeable that parasites are somewhat more active in Texas than in Louisiana, and the difference shown probably indicates fairly correctly the degree of adaptation to weevil conditions which the Texas parasites have undergone. This seems especially true in view of the fact that a general average of observations upon parasite attack made in Texas four years ago also showed 3 per cent, as do the Louisiana localities in 1906.

In comparing the figures given for each class of forms in the two States some peculiar conditions are noticeable. Among hanging forms in Louisiana the total mortality averaged 48.6 per cent, while for the same class of forms in Texas the total mortality averaged but 37.9 per cent. On the other hand, for fallen forms in Louisiana the average was 39.6 per cent, while in Texas it was 57.9 per cent. The reason why the percentage of mortality is higher in hanging forms than it is in fallen forms in Louisiana while it is higher in fallen than in hanging forms in Texas is not apparent. A tabular statement of these differences presents them most clearly:

State and class of forms.		Mortality caused by—			Total mortality.
		Heat.	Ants.	Parasites.	
Louisiana	Hanging	15.5	26.2	6.9	48.6
	Fallen	6.9	32.2	0.5	39.6
Texas	Hanging	12.0	16.5	9.4	37.9
	Fallen	25.3	29.7	3.1	57.9

The conclusion that is strikingly apparent is that, for some reason, the mortality among the forms on the ground is much greater in Texas than it is in Louisiana from the factor of heat or drying. As is shown in Table VII, the temperature differences are not sufficient to account for the disparity if the conditions of exposure to the sunshine were at all similar. The difference of 3.5 per cent among the hanging forms is not great and it seems reasonable to assume that a generally more dense shade may have protected the fallen forms in Louisiana. This would possibly favor ant work but be unfavorable for destruction by heat and by parasites in fallen forms.

From Table X, as a basis of comparison of areas which have been infested for different periods of time, it appears that in the territory infested but about two years the parasite attack amounts to only about two-thirds as much as it does where the weevils have been present for an average of five years. In neither case are they sufficiently abundant to be considered as a factor of great importance at present, but recent experiments indicate that it may be possible to greatly increase their utility in the future. The Solenopsis ants do not seem to require a long period of time to become accustomed to the weevil's presence, but attack the stages readily and probably in proportion to the abundance of the ants. It would seem that the effectiveness of heat may have been increased by the methods of cultivation of cotton which have been adopted by the planters in the older infested region in Texas.

EFFICIENCY OF NATURAL CONTROL IN VARIOUS SECTIONS.

In the sectional reports of the Weather Bureau for Texas the localities from which observations are reported are divided into seven sections, according to their geographic location and their similarity in regard to climatic conditions. In making a more detailed locality study of the natural control of the boll weevil, it seems advisable to group the localities which have been examined upon the same general basis as has been done in grouping them for weather observations. The first two groups, western Louisiana and eastern Texas, have very similar conditions of climate, soil, flora, and fauna. In the group designated as southern Texas are found those localities which are included in the Weather Bureau reports as in the "coast" district, together with Cuero and Hallettsville from the "southwestern" district. These localities would seem to be more closely identified with the conditions of the coast district than with those of southwestern Texas so far as weevil conditions are concerned. For our present purposes, therefore, we have formed five groups of localities in Texas and one in western Louisiana. It is somewhat unfortunate that the limitations of the printed page prevent the association of all the data which should be considered in a study of this kind, and it is also realized that it is a difficult matter to make comparisons and to draw conclusions from a table even as extensive as is Table XI. We believe, however, that it is better to present these data, so that anyone who may care to study the subject more fully than can be done in this bulletin may have the opportunity of referring to these figures.

TABLE XI.—*Mortality in various classes of forms in six sections of area examined.*

WESTERN LOUISIANA.

Kind of forms examined, and locality.	Date.	Number of forms examined.	Weevil stages alive.				Weevil stages dead from heat or drying.			Mortality from heat, etc., by stages, per cent.			Killed by heat or drying.		Killed by ants.		Killed by parasites.		Total number of weevil stages found.	Total per cent of mortality from three causes.
			Larva.	Pupa.	Adult.		Larva.	Pupa.	Adult.	Larva.	Pupa.	Adult.	Number of stages.	Per cent of total stages found.	Number of stages.	Per cent of total stages found.	Number of stages.	Per cent of total stages found.		
					Present.	Emerged.														
Hanging, dried bolls:																				
Johnsons Bayou																				
Mansfield	Sept. 24–29	1,705	38	47	77	112	18	19	22	32.2	28.8	10.4	59	9.4	199	31.9	37	6.0	624	......
Many	Aug. 23	1,250	43	103	84	117	25	21	32	36.8	17.0	13.7	78	14.5	53	10.0	32	6.0	539	......
Orangeville																				
Total		2,955	81	150	161	229	43	40	54	34.7	21.0	12.2	137	11.8	252	21.7	69	6.0	1,163	39.4
Hanging, dried squares:																				
Johnsons Bayou																				
Mansfield	Aug. 24	435	1	2	5	61	27	13	10	96.4	86.7	13.2	50	20.3	119	48.4	7	2.8	246	......
Many	Aug. 23	833	2	42	27	186	79	27	19	97.5	39.1	8.2	125	20.8	155	25.8	63	10.5	601	......
Orangeville																				
Total		1,268	3	44	32	247	106	40	29	97.2	47.4	9.4	175	20.7	274	32.3	70	8.3	847	61.3
Fallen bolls:																				
Johnsons Bayou																				
Mansfield	Aug. 24–Sept. 29	1,222	40	17	13	30	28	5	1	41.2	22.8	2.3	34	16.1	77	36.5	0	0.0	211	......
Many	Aug. 23	1,089	103	53	46	49	3	4	7	2.8	7.0	6.9	14	4.4	47	14.6	5	1.6	321	......
Orangeville	Aug. 23–Sept. 30	295	13	8	9	11	2	2	2	13.3	20.0	9.0	6	9.0	17	25.4	0	0.0	67	......
Total		2,506	156	78	68	90	33	11	10	17.5	12.4	6.0	54	9.0	141	23.5	5	0.8	599	33.4
Fallen squares:																				
Johnsons Bayou	Aug. 22–27	300	106	80	19	17	0	1	0	0.0	1.2	0.0	1	0.4	1	0.4	0	0.0	225	......
Mansfield	Aug. 24–Sept. 29	962	36	31	12	104	46	18	6	56.1	36.7	4.9	70	14.6	218	45.3	2	0.4	481	......
Many	Aug. 23	2,008	105	218	48	325	60	16	6	36.4	6.8	1.6	82	6.0	479	35.0	5	0.4	1,367	......
Orangeville	Sept. 23–30	900	89	71	25	58	5	2	0	5.3	2.7	0.0	7	1.6	161	37.0	5	1.1	435	......
Total, fallen squares		4,170	336	400	104	504	111	37	12	24.8	10.5	2.0	160	6.4	859	34.3	12	0.4	2,508	41.1
Total, fallen bolls.		2,506	156	78	68	90	33	11	10	17.5	12.4	6.0	54	9.0	141	23.5	5	0.8	599	33.4
Total, hanging squares		1,268	3	44	32	247	106	40	29	97.2	47.4	9.4	175	20.7	274	32.3	70	8.3	847	61.3

Total, hanging bolls		2,955	81	150	161	229	43	40	54	34.7	21.0	12.2	137	11.8	252	21.7	69	6.0	1,163	39.4
Total, all forms, western Louisiana		10,899	576	672	365	1,070	293	128	105	50.9	20.5	7.3	526	10.3	1,526	29.9	156	3.0	5,117	43.2

EASTERN TEXAS.

Hanging, dried bolls:																				
Marshall	Aug. 22	173	12	9	5	8	4	......	......	25.0	0.0	0.0	4	7.7	7	13.5	7	13.5	52	......
Overton	Aug. 23	210	9	15	8	10	4	2	1	30.8	11.8	5.3	7	7.9	32	36.0	4	4.5	89	......
Palestine	Aug. 10	510	77	46	23	27	6	0	0	7.2	0.0	0.0	6	2.8	8	3.8	7	3.3	211	......
Trinity	Aug. 9 and 30	1,330	64	59	17	45	7	2	3	9.9	3.3	4.6	12	4.5	27	10.0	28	10.4	269	......
Total		2,223	162	129	53	90	21	4	4	11.5	3.0	2.7	29	4.7	74	11.9	46	7.4	621	24.0
Hanging, dried squares:																				
Overton	Aug. 23	56	1	0	1	8	1	0	0	50.0	0.0	0.0	1	2.2	33	73.3	1	2.2	45	......
Palestine	Aug. 10	468	24	94	56	57	51	11	5	68.0	10.5	4.2	67	17.2	37	9.5	48	12.3	390	......
Trinity	Aug. 9 and 30	276	5	16	8	28	26	6	2	84.0	27.3	5.2	34	20.0	49	29.0	21	12.4	169	......
Total		800	30	110	65	93	78	17	7	72.2	13.4	4.2	102	17.0	119	19.7	70	11.6	604	48.2
Fallen bolls:																				
Marshall	Aug. 22	227	8	2	0	0	6	2	0	42.6	50.0	0.0	8	44.4	0	0.0	0	0.0	18	......
Overton	Aug. 23	375	29	9	5	0	4	0	0	12.1	0.0	0.0	4	4.7	44	48.4	0	0.0	91	......
Palestine	Aug. 10-Sept. 4	578	128	31	15	13	11	0	0	8.0	0.0	0.0	11	5.2	5	2.8	1	0.5	209	......
Trinity	Aug. 9 and 30	4,390	279	69	24	32	122	12	8	30.4	14.8	12.5	142	14.5	403	40.3	4	4.0	976	......
Total		5,570	444	111	44	45	143	14	8	24.4	11.2	8.2	165	12.8	452	36.2	5	0.4	1,294	49.4
Fallen squares:																				
Marshall	Aug. 22	52	7	4	1	0	3	0	1	30.0	0.0	50.0	4	17.4	7	30.4	0	0.0	23	......
Overton	Aug. 23	312	5	6	0	2	11	4	1	68.7	40.0	33.3	16	8.1	166	84.3	2	1.0	197	......
Palestine	Aug. 10-Sept. 4	1,335	323	408	62	75	131	24	1	29.0	55.6	0.7	156	14.9	6	0.6	14	1.3	1,048	......
Trinity	Aug. 9 and 30	2,641	403	115	34	92	105	13	2	20.7	10.2	1.6	120	7.7	641	41.3	18	1.2	1,552	......
Total, fallen squares		4,340	738	533	97	169	250	41	5	25.3	7.2	2.0	296	10.5	820	29.1	34	1.2	2,820	40.8
Total, fallen bolls		5,570	444	111	44	45	143	14	8	24.4	11.2	8.2	165	12.8	452	36.2	5	0.4	1,294	53.0
Total, hanging squares		800	30	110	65	93	78	17	7	72.2	13.4	4.2	102	17.0	119	19.7	70	11.6	604	48.2
Total, hanging bolls		2,223	162	129	53	90	21	4	4	11.5	3.0	2.7	29	4.7	74	11.9	46	7.4	621	24.0
Total, all forms, eastern Texas		12,933	1,374	883	259	397	492	76	24	35.8	8.6	3.7	592	11.1	1,465	27.4	155	2.9	5,339	41.4

TABLE XI.—*Mortality in various classes of forms in six sections of area examined*—Continued.

SOUTHERN TEXAS.

Kind of forms examined, and locality.	Date.	Number of forms examined.	Weevil stages alive.				Weevil stages dead from heat or drying.			Mortality from heat, etc., by stages, per cent.			Killed by heat or drying.		Killed by ants.		Killed by parasites.		Total number of weevil stages found.	Total per cent of mortality from three causes.
					Adult.															
			Larva.	Pupa.	Present.	Emerged.	Larva.	Pupa.	Adult.	Larva.	Pupa.	Adult.	Number of stages.	Per cent of total stages found.	Number of stages.	Per cent of total stages found.	Number of stages.	Per cent of total stages found.		
Hanging, dried bolls:																				
Cuero	Aug. 9-31	276	88	29	26	8	1	1	2	1.1	3.3	5.6	4	2.1	25	13.2	2	1.1	189	......
Goliad	Aug. 7-Sept. 3	530	81	53	52	32	1	3	......	1.2	5.4	0.0	4	1.5	20	7.5	13	5.0	265	......
Hallettsville	Aug. 9-30	1,240	71	67	61	24	19	2	1	21.1	2.9	1.2	22	8.1	16	5.8	11	4.0	273	......
Victoria	Sept. 1	315	68	27	30	16	12	2	5	15.0	6.9	9.8	19	9.5	48	23.9	1	0.5	201	......
Total		2,361	308	176	169	80	33	8	8	9.7	4.3	3.1	49	5.3	109	11.6	27	2.9	928	20.0
Hanging, dried squares:																				
Cuero	Aug. 9-31	931	97	60	40	16	85	4	1	46.7	6.2	1.7	90	20.6	32	7.3	87	20.0	438	......
Goliad	Aug. 7-Sept. 3	337	7	25	20	59	14	3	2	66.7	10.7	24.7	19	9.1	48	23.0	29	13.9	209	......
Hallettsville	Aug. 9-30	602	16	45	80	53	38	8	9	70.4	15.1	6.3	55	13.8	110	27.8	37	9.3	399	......
Victoria	July 2-Sept. 1	1,158	119	161	69	83	140	10	8	54.1	5.8	5.0	158	19.7	111	13.8	82	10.2	802	......
Total		3,028	239	291	209	211	277	25	20	53.7	8.0	4.5	322	17.3	301	16.3	235	12.7	1,848	47.0
Fallen bolls:																				
Beeville	July 12-Sept. 2	2,116	75	33	26	22	60	7	4	44.4	17.5	7.7	71	22.0	92	28.4	0	0.0	324	......
Brownsville	July 28-Sept. 5	1,820	69	59	69	107	18	2	8	20.7	3.3	4.3	28	7.3	24	6.3	13	3.7	384	......
Corpus Christi	July 10	321	8	8	2	1	1	0	0	11.1	0.0	0.0	1	5.0	0	0.0	0	0.0	20	......
Cuero	Aug. 31	282	16	10	0	3	18	6	2	53.0	37.5	40.0	26	32.5	25	31.3	0	0.0	80	......
Goliad	Sept. 3	488	64	29	8	11	9	1	1	12.3	3.3	5.0	11	8.3	5	3.8	3	2.3	133	......
Hallettsville	Aug. 30	902	11	2	2	4	18	5	4	62.1	71.4	40.0	27	29.0	46	49.5	1	1.1	93	......
Victoria	June 10-Sept. 1	2,351	171	53	6	3	17	9	0	9.0	14.5	0.0	26	9.2	19	6.8	0	0.0	281	......
Total		8,280	414	194	113	151	141	30	19	25.4	13.4	6.7	190	14.4	208	16.0	17	1.3	1,315	31.8
Fallen squares:																				
Beeville	July-Oct	3,312	83	70	31	69	422	71	18	83.2	50.0	15.3	511	19.2	1,774	67.1	36	13.2	2,644	......
Brownsville	July 28-Sept. 29	7,142	105	423	321	439	989	145	49	90.4	25.5	6.1	1,183	38.2	380	12.3	194	6.3	3,095	......
Corpus Christi	July 10	718	12	20	8	30	162	17	2	92.5	46.0	5.0	181	41.3	124	28.3	16	9.0	438	......
Cuero	Aug. 31	1,550	13	18	8	17	455	110	12	97.2	86.0	32.4	577	54.7	340	32.1	11	2.4	1,059	......

Goliad	Sept. 3	1,305	65	74	52	90	166	68	7	71.8	48.0	7.2	241	29.4	198	24.1	70	8.5	821	......
Hallettsville	Aug. 30	1,380	18	15	1	17	380	76	12	95.5	83.5	40.0	468	28.7	474	45.6	5	4.8	1,040	......
Victoria	June-Sept	8,004	1,054	384	121	303	1,787	53	8	62.2	12.1	1.9	1,848	28.5	2,010	31.0	200	3.1	6,488	......
Total, fallen squares		23,411	1,350	1,004	542	965	4,361	540	108	75.0	31.8	6.1	5,009	31.2	5,300	36.0	532	3.6	15,585	70.7
Total, fallen bolls		8,280	414	194	113	151	141	30	19	25.4	13.4	6.7	190	14.4	211	16.0	17	1.3	1,315	31.8
Total, hanging squares		3,028	239	291	209	211	277	25	20	53.7	8.0	4.5	322	17.3	301	16.3	235	12.7	1,848	47.0
Total, hanging bolls		2,361	308	176	169	80	33	8	8	9.7	4.3	3.1	49	5.3	109	11.6	27	2.9	9.28	20.0
Total, all forms, southern Texas		37,080	2,311	1,665	1,033	1,407	4,812	603	155	67.6	26.6	6.6	5,570	28.3	5,921	30.0	811	4.1	19,674	62.6

CENTRAL TEXAS.

Hanging, dried bolls:																				
Calvert	Aug. 22-Sept. 13	901	17	35	41	23	17	2	1	50.0	5.4	1.5	20	11.5	25	13.8	12	6.6	181	......
Corsicana	Aug. 23	1,250	29	40	26	44	14	0	0	32.6	0.0	0.0	14	8.0	13	7.4	6	3.4	176	......
Taylor	Aug. 16	125	20	11	1	3	0	0	0	0.0	0.0	0.0	0	0.0	2	5.0	1	2.5	40	......
Waco	July 25-Oct. 12	2,630	55	72	137	268	70	8	32	56.0	10.0	9.3	110	11.4	194	20.2	94	9.8	961	......
Total		4,906	121	158	205	338	101	10	33	45.5	6.0	5.7	144	10.4	234	17.2	113	8.4	1,358	28.8
Hanging, dried squares:																				
Calvert	Aug. 22-Sep. 13	207	6	5	2	11	21	3	0	74.1	37.5	0.0	24	29.6	20	24.7	8	9.9	81	......
Corsicana	Aug. 23	125	4	9	7	12	18	2	2	81.8	18.2	9.5	22	25.9	19	22.4	12	14.1	85	......
Taylor	Aug. 16	116	21	23	12	3	7	2	0	25.0	8.0	0.0	9	11.4	2	2.5	8	10.1	79	......
Waco	July 25-Oct. 12	928	9	23	6	78	113	3	9	92.6	11.5	9.7	125	27.1	87	18.9	126	27.3	461	......
Total		1,376	40	60	27	104	159	10	11	80.0	14.3	7.1	180	25.5	128	18.1	154	21.8	706	65.4
Fallen bolls:																				
Calvert	Aug. 28-Sept. 13	913	203	113	9	2	2	1	0	1.0	0.9	0.0	3	0.9	4	1.2	0	0.0	347	......
Corsicana	Sept. 18	310	2	1	0	3	9	8	3	81.8	88.9	50.0	20	58.5	4	11.8	2	5.9	34	......
Taylor	Aug. 16	310	21	8	0	1	0	0	0	0.0	0.0	0.0	0	0.0	0	0.0	0	0.0	34	......
Waco	July 25-Oct. 12	2,933	110	43	15	31	27	23	19	20.0	34.8	29.0	69	18.1	98	25.7	7	1.8	381	......
Total		4,466	336	165	24	37	38	32	22	10.2	16.2	26.5	92	11.6	106	13.3	9	1.1	796	26.0
Fallen squares:																				
Calvert	Aug. 28-Sept. 13	1,386	88	349	132	93	9	7	1	9.2	2.0	0.4	17	1.6	105	10.0	15	1.5	1,039	......
Corsicana	Sept. 18	26	1	0	0	1	3	1	0	75.0	100.0	0.0	4	25.0	10	62.5	0	0.0	16	......
Taylor	Aug. 16	246	74	38	8	3	27	0	0	26.7	0.0	0.0	27	17.0	0	0.0	1	0.7	153	......
Waco	July 25-Oct. 12	4,318	205	153	66	110	483	71	38	70.2	31.7	17.8	592	34.2	554	32.0	151	8.8	1,731	......
Total, fallen squares		5,976	368	540	206	207	522	79	39	58.6	12.7	8.6	640	21.7	669	22.7	167	5.7	2,939	50.0
Total, fallen bolls		4,466	336	165	24	37	38	32	22	10.2	16.2	26.5	92	11.6	106	13.3	9	1.1	796	26.0
Total, hanging bolls		4,906	121	158	205	338	101	10	33	45.5	6.0	5.7	144	10.4	234	17.2	113	8.4	1,358	28.8

TABLE XI.—*Mortality in various classes of forms in six sections of area examined*—Continued.

CENTRAL TEXAS—Continued.

Kind of forms examined, and locality.	Date.	Number of forms examined.	Weevil stages alive.				Weevil stages dead from heat or drying.			Mortality from heat, etc., by stages, per cent.			Killed by heat or drying.		Killed by ants.		Killed by parasites.		Total number of weevil stages found.	Total per cent of mortality from three causes.
					Adult.															
			Larva.	Pupa.	Present.	Emerged.	Larva.	Pupa.	Adult.	Larva.	Pupa.	Adult.	Number of stages.	Per cent of total stages found.	Number of stages.	Per cent of total stages found.	Number of stages.	Per cent of total stages found.		
Total, hanging squares	....	1,386	40	60	27	104	159	10	11	80.0	14.3	7.1	180	25.5	128	18.1	154	21.8	706	65.4
Total, all forms, central Texas	....	16,734	865	923	462	686	820	131	105	48.7	12.4	8.4	1,056	18.2	1,137	19.8	443	7.8	5,799	45.5
NORTHEASTERN TEXAS.																				
Hanging, dried bolls: Dallas	Aug. 29–Oct. 15	4,604	144	243	239	255	38	11	18	20.9	4.3	3.5	67	4.9	232	17.0	67	4.9	1,362	26.9
Hanging, dried squares: Dallas	Aug. 29–Oct. 6	225	5	13	7	41	18	0	0	78.3	0.0	0.0	18	16.4	19	17.3	9	8.2	110	41.8
Fallen bolls:																				
Dallas	Aug. 29	367	51	10	0	0	0	0	0	0.0	0.0	0.0	0	0.0	9	12.9	0	0.0	70	......
Fullers	Aug. 17	382	3	0	0	1	0	0	0	0.0	0.0	0.0	0	0.0	0	0.0	0	0.0	4	......
Mineola	Oct. 2	158	21	12	2	0	6	5	3	22.2	29.4	60.0	14	24.6	7	12.3	1	1.8	57	......
Terrell	Sept 19	220	30	11	1	0	0	0	0	0.0	0.0	0.0	0	0.0	3	6.5	0	0.0	46	......
Total	....	1,127	105	33	3	1	6	5	3	5.4	13.2	42.9	14	8.0	19	10.7	1	0.6	177	19.3
Fallen squares:																				
Dallas	Aug. 29	111	14	8	0	7	2	0	0	12.5	0.0	0.0	2	3.6	23	42.6	0	0.0	54	......
Fullers	Aug. 17	100	20	0	0	1	0	0	0	0.0	0.0	0.0	0	0.0	0	0.0	0	0.0	21	......
Mineola	Aug. 10–Oct. 2	917	116	60	7	26	72	61	11	38.3	50.0	30.0	144	32.4	83	18.7	9	2.0	445	......
Terrell	Sept. 19	88	26	19	2	3	1	0	0	3.7	0.0	0.0	1	1.9	0	0.0	0	0.0	53	......
Total, fallen squares	....	1,216	176	87	9	37	75	61	11	30.0	41.2	20.0	147	25.2	106	18.2	9	1.5	573	44.9

Total, fallen bolls		1,127	105	33	3	1	6	5	3	5.4	13.2	42.9	14	8.0	19	10.7	1	0.6	177	19.3
Total, hanging squares		225	5	13	7	41	18	0	0	78.3	0.0	0.0	18	16.4	19	17.3	9	8.2	110	41.8
Total, hanging bolls		4,604	144	243	239	255	38	11	18	20.9	4.3	3.5	67	4.9	232	17.0	67	4.9	1,362	26.9
Total, all forms, northeastern Texas		7,172	430	376	258	334	137	77	32	24.2	17.0	5.1	246	11.1	376	16.9	86	3.9	2,222	31.9
SOUTHWESTERN TEXAS.																			
Hanging, dried bolls:																			
San Antonio		310	0	0	0	0	0	0	0	0.0	0.0	0.0	0	0.0	1	100.0	0	0.0	1	100.0
Hanging, dried squares																				
Roosevelt	Sept. 25	216	20	19	5	10	6	1	0	23.1	5.0	0.0	7	8.6	18	22.2	2	2.5	81	......
San Antonio	Aug. 15	91	8	0	0	2	0	0	0	0.0	0.0	0.0	0	0.0	24	70.6	0	0.0	34	......
Total		307	28	19	5	12	6	1	0	21.4	5.0	0.0	7	6.1	42	36.5	2	1.7	115	44.3
Fallen bolls:																				
Junction	Sept. 24	44	5	2	0	1	3	0	0	37.0	0.0	0.0	3	17.6	5	29.4	1	6.0	17	......
Kerrville	Aug. 26–Sept. 4	500	215	41	10	2	9	0	0	4.0	0.0	0.0	9	3.1	7	1.4	7	1.4	295	......
Lula	Sept. 26	46	26	11	1	0	0	0	0	0.0	0.0	0.0	0	0.0	7	13.7	0	0.0	51	......
Roosevelt	Sept. 24	46	59	8	1	1	0	0	0	0.0	0.0	0.0	0	0.0	3	4.1	0	0.0	74	......
Total		636	305	62	12	4	12	0	0	3.8	0.0	0.0	12	2.7	22	5.0	8	1.8	437	9.6
Fallen squares:																				
Junction	Sept. 24	383	11	10	2	22	33	1	3	75.0	9.1	11.1	37	28.7	33	25.6	11	8.5	129	......
Kerrville	Aug. 20–Sept. 3	46	14	10	0	0	1	0	0	6.7	0.0	0.0	1	3.0	6	17.1	4	11.4	35	......
Lula	Sept. 26	278	22	12	6	3	2	0	0	8.3	0.0	0.0	2	3.6	3	5.6	0	0.0	54	......
Roosevelt	Sept. 24	88	16	13	5	7	8	1	0	33.3	7.1	0.0	9	13.0	10	14.5	9	13.0	69	......
Total, fallen squares		795	63	45	13	32	44	2	3	41.1	4.3	6.2	49	17.0	52	18.1	24	8.5	287	43.6
Total, fallen bolls		636	305	62	12	4	12	0	0	3.8	0.0	0.0	12	2.7	22	5.0	8	1.8	437	9.6
Total, hanging squares		307	28	19	5	12	6	1	0	21.4	5.0	0.0	7	6.1	42	36.5	2	1.7	115	44.3
Total, hanging bolls		310	0	0	0	0	0	0	0	0.0	0.0	0.0	0	0.0	1	100.0	0	0.0	1	100.0
Total, all forms, southwestern Texas		2,048	396	126	30	48	62	3	3	13.5	2.3	3.7	68	8.1	117	13.9	34	4.0	840	26.0

A casual examination of the data given in Table XI will be sufficient to show that considerable variation exists in the mortality produced by each factor in the same class of forms in even the most closely associated localities. This seems to prove the influence of local conditions affecting the mortality produced by the different factors. From several considerations this would seem to be an encouraging fact, indicating that it may be possible to change unfavorable conditions or to take advantage of those which are most favorable in regard to environment, cultivation, soil, etc. It is noticeable that in all classes of forms, in practically all localities, a large proportion of the mortality from heat occurs during the larval stage. In southern Texas alone does the larval mortality in hanging dried squares fall below that in any other class of forms. In that case three-fourths of all larvæ found in fallen squares were killed by heat, while in the hanging squares slightly more than one-half were thus killed. As a general average for the entire area about 53 per cent of the larvæ, 18 per cent of the pupæ, and 6 per cent of the adults had been killed by heat. These percentages are very nearly in the ratio of nine, three, and one. It appears that the nearer the weevil stage approaches maturity the less susceptible is it to the adverse influence of heat or drying. This shows how important it is that the spacing of the plants be such as will submit the largest possible proportion of fallen forms to the direct influence of sunshine. Whatever spacing may have been found advisable where weevils were not present, there can now be no question about the general soundness of the recommendation for increasing the space allowed each plant wherever the weevil is present in abundance. It is true that the efficiency of this factor under similar cultural conditions may vary widely during different seasons, and during different portions of the same season, but in any case the data given would seem sufficiently reliable to prove that under nearly all conditions, with the weevil present, wide spacing is advantageous.

It was found impracticable to determine the effect of ant attack upon the various stages of the weevil. It may be stated that, in general, parasites were found to attack the weevil during the last few days of the larval stage. A considerable number of parasitized pupæ were found, and in a very few cases the weevil had become adult before death was caused by the parasite. As the parasite causes the death of its host very quickly after beginning its attack, the time required for the egg stage of the parasite should be taken into consideration in determining the time of attack, but it has been impossible, as yet, to determine the egg stage for any of the parasites of the weevil.

MORTALITY IN EACH CLASS OF FORMS FOR EACH SECTION.

Some additional points in the comparison of the general results shown in Table XI may be more conveniently shown by such arrangement of the totals and average percentages as is given in Table XII.

TABLE XII.—*Comparison of mortality results by class of forms and section of State.*

Class of fruit and section of State.	Total number of forms examined.	Total number of stages found.	Total number of stages destroyed.			Mortality percentage.			Total mortality—three factors.	Rank of section by total mortality.
			Heat.	Ants.	Parasites.	Heat.	Ants.	Parasites.		
Dried hanging bolls:						*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
Western Louisiana	2,955	1,163	137	252	69	11.8	21.7	6.0	39.4	2
Eastern Texas	2,223	621	29	74	46	4.7	11.9	7.4	24.0	5
Southern Texas	2,361	928	49	109	27	5.3	11.6	2.9	20.0	6
Central Texas	4,906	1,358	144	234	113	10.4	17.2	8.4	28.8	3
Northern Texas	4,604	1,362	67	232	67	4.9	17.0	4.9	26.9	4
Southwestern Texas	310	1	0	1	0	0.0	100.0	0.0	100.0	1
	17,359	5,433	426	902	322	7.8	16.6	6.0	30.4	....
Dried hanging squares:										
Western Louisiana	1,268	847	175	274	70	20.7	32.3	8.3	61.3	2
Eastern Texas	800	604	102	119	70	17.0	19.7	11.3	48.2	3
Southern Texas	3,028	1,848	322	301	235	17.3	16.3	12.7	47.0	4
Central Texas	1,376	706	180	128	154	25.5	18.1	21.8	65.4	1
Northern Texas	225	110	18	19	9	16.4	17.3	8.2	41.8	6
Southwestern Texas	307	115	7	42	2	6.1	36.5	1.7	44.3	5
	7,004	4,230	804	883	540	19.0	20.9	12.8	52.6	....
Fallen bolls:										
Western Louisiana	2,606	599	54	141	5	9.0	23.5	0.8	33.4	2
Eastern Texas	5,570	1,294	165	452	5	12.8	36.2	4.0	50.0	1
Southern Texas	8,280	1,315	190	211	17	14.4	16.0	1.3	31.8	3
Central Texas	4,466	796	92	106	9	11.6	13.3	1.1	26.0	4
Northern Texas	1,127	177	14	19	1	8.0	10.7	0.6	19.2	5
Southwestern Texas	636	437	12	22	8	2.7	5.0	1.8	9.6	6
	22,685	4,618	527	951	45	11.4	21.0	1.0	33.4	....
Fallen squares:										
Western Louisiana	4,170	2,508	160	859	12	6.4	34.2	0.4	43.0	5
Eastern Texas	4,340	2,820	296	820	34	10.5	39.1	1.2	40.8	6
Southern Texas	23,411	15,583	5,009	5,280	532	31.2	36.0	3.6	70.7	1
Central Texas	5,976	2,939	640	669	167	21.7	22.7	5.7	50.0	2
Northern Texas	1,216	573	147	106	9	25.2	18.2	1.5	44.9	3
Southwestern Texas	795	287	49	52	24	17.0	18.1	8.5	43.6	4
	39,908	24,710	6,301	7,786	778	25.5	32.8	3.3	60.8	....

In Table XII one of the most striking points is the rather uniformly high percentage of parasitism in each section found in dried hanging bolls and squares. By far the highest percentage of parasitism is the 21.8 per cent shown in dried squares in central Texas. Western Texas leads in the percentage of parasitism in fallen squares, but when the comparatively small number (287) of weevil stages found is considered, it would appear that 8.5 per cent may be largely in excess of the percentage which would have been found in so extensive a series of observations as was made in central or southern Texas. A similar exception should be noted for the 100 per cent of mortality from ant work in dried hanging bolls in western Texas where only a single weevil stage was found. In dried hanging squares the mortality from heat, as a general rule, very nearly equals that from ant attack, while in other classes of forms ants destroyed many more stages of the weevil than did heat and parasites together.

In regard to ant work, it is evident that the high percentage shown among fallen squares in each of the six sections examined is very important. This is especially so because of the fact that these percentages apply to the largest series of examinations made, the number of weevil stages found in this class of forms being somewhat more than 60 per cent of the total. Eastern Texas, southern Texas, and western Louisiana seem to have profited most by the work of the ants in fallen squares, and these same sections show the highest percentages of ant work in fallen bolls, as might naturally be expected.

The wide diversity of conditions under which the ants successfully attack the weevil is another one of the encouraging features shown by this work. It proves in a very reassuring way the general distribution of this species of Solenopsis and their activity in destroying weevil stages in every class of forms and in all parts of the infested area. The value of the work which they do in restraining the weevil multiplication can not be estimated. Their work henceforth will be more fully appreciated and a careful study will be made of the life history of the species and of the possibility of producing an increase in its efficiency.

SECTIONS PROFITING MOST BY NATURAL CONTROL.

Still another arrangement of this same series of results will show most plainly a comparison of the total mortality in the four classes of forms for each of the six sections into which the localities have been grouped. In Table XIII are shown the general results of the examinations.

TABLE XIII.—*Comparison of total mortality results according to section.*

Section.	Total forms examined.	Weevil stages alive.				Weevil stages dead from heat or drying.			Mortality from heat, etc., by stages.		
		Larva.	Pupa.	Adult.		Larva.	Pupa.	Adult.	Larva.	Pupa.	Adult.
				Present.	Emerged.						
									Per ct.	*P. ct.*	*Per ct.*
Western Louisiana	10,999	576	672	365	1,070	293	138	105	50.9	20.5	7.3
Eastern Texas	12,933	1,374	883	259	397	492	76	24	35.8	8.6	3.7
Southern Texas	37,080	2,311	1,665	1,033	1,407	4,812	603	155	67.6	26.6	6.0
Central Texas	16,724	865	923	462	686	820	131	105	48.7	12.4	8.4
Northeastern Texas	7,172	430	376	258	334	137	77	32	24.2	17.0	5.1
Southwestern Texas	2,048	396	126	30	48	62	3	3	1.6	2.4	3.8
	86,956	5,952	4,645	2,407	3,942	6,616	1,018	424	52.6	18.0	6.3

Section.	Killed by heat or drying.		Killed by ants.		Killed by parasites.		Total number of weevil stages found.	Total per cent of mortality from three causes.	Rank of section in percentage of mortality.
	Number of stages.	Per cent of total stages found.	Number of stages.	Per cent of total stages found.	Number of stages.	Per cent of total stages found.			
Western Louisiana	526	10.3	1,526	29.9	156	3.0	5,117	43.2	3
Eastern Texas	592	11.1	1,465	27.4	155	2.9	5,339	41.4	4
Southern Texas	5,570	28.3	5,921	30.0	811	4.1	19,674	62.6	1
Central Texas	1,056	18.2	1,137	19.8	443	7.8	5,799	45.5	2
Northeastern Texas	246	11.1	376	16.9	86	3.9	2,222	31.9	5
Southwestern Texas	68	8.1	117	13.9	34	4.0	840	26.0	6
	8,058	20.7	10,542	27.0	1,685	4.3	38,991	52.0	......

Many of the conclusions which might be drawn from Table XIII have already been stated in connection with preceding tables. The last column shows that southern Texas enjoys the benefits of natural control to a larger degree than does any other section. In that section 62.6 per cent (nearly two-thirds) of all stages found had been destroyed. One half of this mortality was accomplished by ants, the other half by heat and parasites combined. Central Texas stands next, with a total mortality of 45.5 per cent. In this section, while the effectiveness of heat and of ants had decreased, that of parasites had considerably increased. The increase in parasite attack, however, was by no means sufficient to counterbalance the decrease from the other two factors. Western Louisiana and eastern Texas, with 43.2 and 41.4 per cent of total mortality, respectively, show very close agreement in the proportions of mortality from each factor. This close agreement might be anticipated because of the similarity in soil, climatic, and cultural conditions prevailing in those adjacent sections. The principal reason for separating the localities into these two sections was to facilitate a comparison of the recently infested territory of Louisiana with the older-infested sections of Texas. In this respect, also, but little difference exists between eastern Texas and western Louisiana. In analyzing the factors producing the closely similar total percentages of mortality in western Louisiana and in central Texas it will be seen that there were very essential differences. In western Louisiana nearly 70 per cent of the total mortality found was due to ant attack, while in central Texas only 43.5 per cent was due to ants. It is evident that in central Texas may be found the conditions which are most favorable to parasite attack. An extended study is being made of the entire field of parasitic attack upon the boll weevil, and part of the results previously obtained may be found in Bulletin 73 of this Bureau. By far the lowest proportion of total mortality is that found for southwestern Texas. Most of the localities included in this section have but recently become infested. It would appear, however, that in the higher altitude of those localities heat may not be quite as effective and that ants may not be as abundantly distributed as they are in other sections of the State. The observations in this locality have not extended over a sufficient period to justify any general conclusions regarding the result of the smaller degree of natural control which would appear from the observations made. It is quite possible that other factors than these which are here considered may serve to check the weevil in this section. Such a condition as a much larger mortality during the hibernation period might hold the weevils largely in check in spite of the smaller mortality during the summer.

DESTRUCTION OF COTTON FORMS BY WEEVIL ATTACK OR BY NATURAL CAUSES.

It seems advisable in connection with this study of factors concerned in the natural control of the boll weevil to place on record some of the data which have been obtained, showing the proportion of squares and bolls which have been found to be destroyed by weevil attack or which were shed by the plant from natural causes without insect injury.

COLLECTIONS OF FALLEN FORMS IN 1905.

During the season of 1905 quite extensive experiments were made to determine the value of a thorough collection of fallen forms in checking the injury done by the weevil. These experiments showed a net loss. The cost of collecting fallen forms exceeded by several dollars per acre the slight increase in yield shown by the plots from which collections were made as compared with plots under similar conditions, but in which no forms were collected. No examinations were made of these forms to determine the proportion which had been attacked by the weevil, but from sample lots as shown in Table XIV the proportion of squares and bolls was determined.

TABLE XIV.—*Proportion of squares and bolls among fallen fruit, Texas, 1905.*

Locality.	Date.	Total forms examined.	Squares.		Bolls.	
			Number.	Per cent of total.	Number.	Per cent of total.
Gurley, Tex	Aug. 10–12	498	147	29.5	351	70.5
Do	Aug. 17	2,442	411	16.8	2,031	83.2
Do	Aug. 19	775	239	30.8	536	69.2
Do	Aug. 31	650	240	36.9	410	63.1
Quinlan, Tex	Aug. 24	2,542	472	18.6	2,070	81.4
Waco Tex	Aug. 31	4,036	1,269	31.4	2,767	68.6
Total or average		10,943	2,778	25.4	8,165	74.6

It should be stated that the lots for which figures are given in Table XIV were from the last collections made in those experiments. The picking began early in July, and doubtless a test at that time would have shown a considerably larger proportion of squares. As it was, the average proportion among the nearly 11,000 forms examined was approximately one square to every three small bolls. In the field at Gurley five collections were made in about six weeks. This work extended over one-half of the 16-acre field. Upon this 8 acres about 730,000 fallen forms were collected. According to the proportions shown in Table XV, it would seem conservative to estimate that in this field at Gurley there were collected fallen squares containing from 100,000 to 125,000 weevil stages, and in the fallen bolls from 100,000 to 115,000 stages. From this 8 acres, therefore, there were collected, during July and August, 1905, in all probability from 200,000 to 250,000 weevil stages. If we apply to this number of stages the proportion shown by Table VI to have reached the adult stage in Louisiana and Texas in 1906 (i. e., about 17 per cent), it would appear that this work of collection prevented the emergence of from 34,000 to 42,500 adult weevils upon an area of 8 acres. When it is considered that in spite of this large destruction of weevils the resulting increase in yield averaged hardly 50 pounds of cotton per acre, the reader will be able to realize more clearly than he could without such a comparison the tremendous importance of the factors of natural control which do, under exceptionally favorable conditions, make it possible to produce a very profitable crop, because of their direct effect in reducing the number of weevils which reach maturity. It will be understood, also, that the total mortality resulting from all factors must become very large indeed in order to reduce the damage done by the small percentage which do survive, so that the development of the crop may far outstrip the insect attack.

COLLECTIONS OF FALLEN AND OF DRIED HANGING FORMS IN 1906.

In Tables XV and XVI are presented some of the results from the work of 1906. In these tables, however, it is possible to include a statement of the number of weevil stages found in each examination. In the collection of this material there was no particular selection of squares or bolls, but all forms were taken as they occurred. Special collections were made, however, for hanging and for fallen forms, so that the proportion of hanging and of fallen forms could not be considered as an indication of the proportion which actually existed upon the area from which collections were made. This explanation applies both to Table XV and to Table XVI.

TABLE XV.—*Proportion of fruit destroyed by insect injury or by natural causes, Louisiana, 1906.*

Class of fruit examined, and locality.	Date.	Total examined.	Weevil stages not found.		Infested by weevil.		
			Number of forms.	Per cent of total examined.	Number.	Per cent of total.	Total weevil stages found.
Fallen bolls:							
Mansfield	Aug. 24	450	392	87.1	58	12.9	58
Mansfield	Aug. 24	400	300	75.0	100	25.0	106
Mansfield	Sept. 29	372	332	89.2	40	10.8	47
Many	Aug. 23	555	402	72.4	153	27.6	153
Many	Aug. 23	534	396	74.2	138	25.8	168
Orangeville	Aug. 23	145	109	75.2	36	24.8	36
Orangeville	Sept. 30	150	119	79.3	31	20.7	31
Totals, fallen bolls		2,606	2,050	78.7	556	21.3	599
Fallen squares:							
Johnsons Bayou	Aug. 22–27	300	78	26.0	222	74.0	225
Mansfield	Aug. 24	400	193	48.25	207	51.75	207
Mansfield	Aug. 24	525	268	51.0	257	49.0	257
Mansfield	Sept. 29	37	20	54.1	17	45.9	17
Many	Aug. 23	875	336	38.4	539	61.6	539
Many	Aug. 23	1,133	407	35.9	726	64.1	728
Orangeville	Aug. 23	400	142	35.5	258	64.5	259
Orangeville	Aug. 23	500	332	66.4	168	33.6	176
Totals, fallen squares		4,170	1,776	42.6	2,394	57.4	2,408

TABLE XV.—*Proportion of fruit destroyed by insect injury or by natural causes, Louisiana, 1906*—Continued.

Class of fruit examined, and locality.	Date.	Total examined.	Weevil stages not found.		Infested by weevil.		
			Number of forms.	Per cent of total examined.	Number.	Per cent of total.	Total weevil stages found.
Hanging bolls:							
Mansfield	Aug. 24	1,412	965	68.3	447	31.7	479
Mansfield	Sept. 29	293	190	64.8	103	35.2	145
Many	Aug. 23	125	74	59.2	51	40.8	54
Many	Aug. 23	800	450	56.3	350	43.7	380
Many	Aug. 23	325	228	70.2	97	29.8	105
Totals, hanging bolls		2,955	1,907	64.2	1,048	35.8	1,163
Hanging squares:							
Mansfield	Aug. 24	430	186	43.3	244	56.7	244
Mansfield	Sept. 29	5	3	60.0	2	40.0	2
Many	Aug. 23	115	27	23.5	88	76.5	88
Many	Aug. 23	466	136	29.2	330	70.8	330
Many	Aug. 23	252	69	27.4	183	72.6	183
Totals, hanging squares		1,268	421	33.2	847	66.8	847
Totals, all forms		10,999	6,154	56.0	4,845	44.0	5,017

As is shown in the last line of totals, giving the average percentages for the four classes of forms examined, 56 per cent of the 11,000 forms contained no stage of the weevil. Among 5,561 bolls, including both hanging and fallen bolls, 71 per cent contained no weevil stage, while in the remaining 29 per cent, 1,604 bolls, there were 1,762 weevil stages. This means that in the bolls found to contain weevil stages there were an average of 1.098 stages per boll. Among the 5,438 squares, 40 per cent contained no weevil stage. In the 3,241 squares containing stages there were 3,255 found. In squares, therefore, there were about 1.004 stages for each square. This shows how strictly the multiplication of the weevil is limited by the available supply of squares. An average of squares and bolls shows but 1.035 weevil stages for each form which was found to contain them. Among all bolls but 30 per cent contained a weevil stage, while among all squares 60 per cent were infested. While it is probable that few of the 30 per cent of squares which failed to show some stage of the weevil had really escaped all form of weevil injury, it is equally probable that a very small portion of the 70 per cent of bolls which were found to contain no stage of the weevil had ever been attacked in any way. Thus, while few squares perished regardless of weevil attack, probably more than one-half of all the small bolls which perished had not been attacked in any way by the weevil, though it is possible that in many cases there had been some form of injury to the square or bloom connected with that boll.

In the examination of material from Texas there are so many localities represented for each class of forms that it seems advisable to divide the table into a section for each class.

TABLE XVI.—*Proportion of fruit destroyed by insect injury or by natural causes, Texas, 1906.*

A. HANGING, DRIED BOLLS.

Date.	Locality.	Total bolls examined.	Bolls without weevil stages.		Bolls with weevil stages.		
			Number.	Per cent of total.	Number.	Per cent of total.	Number of weevil stages found.
Aug. 22	Calvert	208	192	92.1	16	7.9	16
Aug. 28	Calvert	311	246	79.1	65	20.9	70
Aug. 31	Calvert	157	137	87.3	20	12.7	20
Sept. 13	Calvert	225	170	75.8	55	24.2	75
Aug. 23	Corsicana	450	391	82.4	59	17.6	59
Aug. 23	Corsicana	800	675	84.4	125	15.6	117
Aug. 9	Cuero	26	20	76.9	6	23.1	6
Aug. 31	Cuero	250	138	55.2	112	44.8	183
Aug. 29	Dallas	232	206	88.8	26	11.2	26
Sept. 12	Dallas	511	408	80.0	103	20.0	103
Sept. 13	Dallas	571	475	83.2	96	16.8	107
Oct. 2	Dallas	450	358	80.0	92	20.0	95
Oct. 2	Dallas	323	220	68.3	103	31.7	157
Oct. 6	Dallas	498	344	69.1	154	30.9	190
Oct. 6	Dallas	505	389	77.0	116	33.0	125
Oct. 6	Dallas	510	425	83.3	85	16.7	96
Oct. 6	Dallas	494	354	71.1	140	38.9	216
Oct. 15	Dallas	510	430	84.3	80	15.7	247
Aug. 7	Goliad	165	132	80.0	33	20.0	33
Sept. 3	Goliad	125	68	54.4	57	45.6	103
Sept. 3	Goliad	240	111	46.2	129	53.8	129
Aug. 9	Hallettsville	370	274	74.1	96	25.9	96
Aug. 30	Hallettsville	870	700	80.0	170	20.0	177
Aug. 22	Marshall	173	133	76.9	40	23.1	52
Aug. 23	Overton	210	121	57.6	89	42.4	89
Aug. 10	Palestine	510	299	58.6	211	41.4	211
Sept. 25	Roosevelt	9	6	66.7	3	33.3	9
Aug. 15	San Antonio	75	74	98.7	1	1.3	1
Aug. 16	Taylor	125	85	68.0	40	32.0	40
Aug. 9	Trinity	605	463	76.5	142	23.5	142
Aug. 30	Trinity	725	603	83.2	122	16.8	127
Sept. 1	Victoria	315	157	50.0	158	50.0	201
July 25	Waco	434	412	95.0	22	5.0	22
Aug. 17	Waco	160	144	90.0	16	10.0	16
Aug. 28	Waco	795	613	77.1	182	22.9	252
Aug. 29	Waco	370	243	65.7	127	34.3	153
Sept. 19	Waco	29	17	58.6	12	41.4	12
Sept. 19	Waco	200	144	72.0	56	38.0	66
Sept. 19	Waco	34	18	53.0	16	47.0	16
Sept. 20	Waco	169	109	64.5	60	35.5	79
Sept. 20	Waco	100	17	17.0	83	83.0	112
Oct. 12	Waco	339	170	50.0	169	50.0	233
Total		14,178	10,691	75.4	3,487	24.6	4,279

TABLE XVI.—*Proportion of fruit destroyed by insect injury or by natural causes, Texas, 1906*—Continued.

B. HANGING, DRIED SQUARES.

Date.	Locality.	Total squares examined.	Squares without weevil stages.		Squares with weevil stages.		
			Number.	Per cent of total.	Number.	Per cent of total.	Number of weevil stages present.
Aug. 22	Calvert	103	97	94.2	6	5.8	6
Aug. 28	Calvert	62	14	22.6	48	77.4	48
Aug. 31	Calvert	18	4	22.2	14	77.8	14
Sept. 13	Calvert	24	13	54.2	11	45.8	13
Aug. 23	Corsicana	72	18	25.0	54	75.0	55
Aug. 23	Corsicana	53	23	43.4	30	56.6	30
Aug. 9	Cuero	106	15	14.2	91	85.8	91
Aug. 31	Cuero	825	481	58.3	344	41.7	347
Aug. 29	Dallas	61	47	77.5	14	22.5	12
Sept. 12	Dallas	31	17	54.8	14	45.2	14
Sept. 13	Dallas	100	36	36.0	64	64.0	64
Oct. 2	Dallas	11	3	27.3	8	72.7	8
Oct. 6	Dallas	8	5	62.5	3	37.5	3
Oct. 6	Dallas	5	1	20.0	4	80.0	4
Oct. 6	Dallas	9	4	44.4	5	55.6	5
Aug. 7	Goliad	35	12	34.3	23	65.7	23
Sept. 3	Goliad	152	68	44.7	84	55.3	84
Sept. 3	Goliad	150	48	32.0	102	68.0	102
Aug. 9	Hallettsville	122	37	30.0	85	70.0	85
Aug. 30	Hallettsville	480	167	34.8	313	65.2	314
Aug. 22	Marshall	12	8	66.7	4	33.3	5
Aug. 23	Overton	56	11	19.6	45	80.4	45
Aug. 10	Palestine	468	78	16.7	390	83.3	390
Sept. 25	Roosevelt	216	136	63.0	80	37.0	81
Aug. 15	San Antonio	6	5	81.7	1	18.3	1
Aug. 16	Taylor	116	37	32.0	79	68.0	81
Aug. 9	Trinity	216	78	36.1	138	63.9	138
Aug. 30	Trinity	60	29	48.3	31	51.7	31
Sept. 1	Victoria	938	293	31.2	645	68.8	654
July 2	Victoria	220	82	37.3	138	62.7	148
July 25	Waco	254	155	61.0	99	39.0	99
Aug. 17	Waco	54	32	59.3	22	40.7	22
Aug. 28	Waco	213	75	35.2	138	64.8	138
Aug. 29	Waco	200	108	54.0	92	46.0	92
Sept. 19	Waco	20	7	35.0	13	65.0	13
Sept. 19	Waco	43	27	62.8	16	37.2	16
Sept. 19	Waco	11	9	81.7	2	18.3	4
Sept. 20	Waco	90	35	38.9	55	61.1	55
Sept. 20	Waco	43	19	44.2	24	55.8	24
Total		5,663	2,334	41.2	3,329	58.8	3,359

TABLE XVI.—*Proportion of fruit destroyed by insect injury or by natural causes, Texas, 1906*—Continued.

C. FALLEN BOLLS.

Date.	Locality.	Total bolls examined.	Bolls without weevil stages.		Bolls with weevil stages.		
			Number.	Per cent of total.	Number.	Per cent of total.	Number of weevil stages found.
July 12	Beeville	140	131	93.6	9	6.4	9
Aug. 8	Beeville	78	59	75.6	19	24.4	19
Aug. 13	Beeville	310	278	90.0	32	10.0	32
Sept. 3	Beeville	1,588	1,328	83.6	260	16.4	264
July 28	Beeville	35	30	85.7	5	14.3	5
Sept. 5	Beeville	1,785	1,428	80.0	357	20.0	379
Aug. 28	Calvert	573	469	85.3	104	14.7	107
Sept. 13	Calvert	340	173	50.9	167	49.1	240
July 10	Corpus Christi	321	301	93.8	20	6.2	20
Sept. 18	Corsicana	310	277	89.4	33	10.6	34
Aug. 31	Cuero	282	219	77.7	63	22.3	80
Aug. 29	Dallas	367	327	89.1	40	10.9	70
Aug. 17	Fullers	382	378	99.0	4	1.0	4
Sept. 3	Goliad	133	104	78.2	29	21.8	44
Sept. 3	Goliad	355	280	80.0	75	20.0	89
Aug. 30	Hallettsville	540	469	86.9	71	13.1	79
Aug. 30	Hallettsville	362	349	96.4	13	3.6	14
Sept. 24	Junction	44	28	63.6	16	36.4	17
Aug. 26	Kerrville	232	132	56.9	100	43.1	100
Sept. 3	Kerrville	268	136	50.1	132	49.9	195
Sept. 26	Lula	46	19	41.3	27	58.7	51
Aug. 22	Marshall	227	210	94.1	17	5.6	18
Oct. 2	Mineola	158	109	69.0	49	31.0	57
Aug. 23	Overton	145	108	77.9	37	22.1	37
Aug. 23	Overton	230	181	78.7	49	21.3	54
Aug. 10	Palestine	460	266	57.8	194	42.2	194
Sept. 4	Palestine	118	104	88.1	14	11.9	15
Sept. 24	Roosevelt	46	12	26.1	34	73.9	74
Aug. 15	San Antonio	235	235	100.0	0	0.0	0
Aug. 16	Taylor	211	180	85.3	31	14.7	31
Sept. 19	Terrell	220	176	80.0	44	20.0	46
Aug. 9	Trinity	908	821	90.4	87	9.6	90
Aug. 9	Trinity	580	517	89.1	63	10.9	67
Aug. 30	Trinity	1,452	803	55.3	649	44.7	659
Aug. 30	Trinity	1,450	1,293	89.2	157	10.8	160
June 23	Victoria	10	10	100.0	0	0.0	0
June 28	Victoria	135	135	100.0	0	0.0	0
July 5	Victoria	885	843	95.3	42	4.7	42
July 18-20	Victoria	420	341	81.2	79	18.8	79
July 22	Victoria	533	442	83.0	91	17.0	91
Sept. 1	Victoria	472	404	85.6	68	14.4	71
July 25	Waco	691	639	92.5	52	7.5	52
Aug. 17	Waco	315	291	92.4	24	7.6	24
Aug. 28	Waco	932	829	89.0	103	11.0	103
Aug. 29	Waco	490	411	83.9	79	16.1	84
Aug. 29	Waco	260	233	89.6	27	10.4	28
Oct. 12	Waco	241	175	72.7	66	27.3	90
Total		20,315	16,683	82.1	3,632	17.9	4,018

TABLE XVI.—*Proportion of fruit destroyed by insect injury or by natural causes, Texas, 1906*—Continued.

D. FALLEN SQUARES.

Date.	Locality.	Total squares examined.	Squares without weevil stages.		Squares with weevil stages.		
			Number.	Per cent of total.	Number.	Per cent of total.	Number of weevil stages found.
July 12	Beeville	900	234	26.0	666	74.0	656
Aug. 8	Beeville	512	76	14.8	436	85.2	436
Aug. 13	Beeville	1,000	126	12.6	874	87.4	874
Sept. 3	Beeville	900	222	24.7	678	75.3	678
July 28	Brownsville	2,524	957	37.9	1,567	62.1	1,568
Aug. 3	Brownsville	130	17	13.8	113	86.2	115
Sept. 5	Brownsville	4,032	2,889	70.3	1,143	29.7	1,147
Sept. 29	Brownsville	456	199	43.6	257	56.4	265
Aug. 28	Calvert	353	40	11.3	313	88.7	315
Sept. 13	Calvert	1,033	341	33.0	692	67.0	722
July 10	Corpus Christi	718	283	39.4	435	60.6	438
Sept. 18	Corsicana	26	10	38.5	16	61.5	16
Aug. 31	Cuero	1,550	495	32.0	1,055	68.0	1,059
Aug. 29	Dallas	111	57	51.4	54	48.6	54
Aug. 17	Fullers	100	79	79.0	21	21.0	21
Sept. 3	Goliad	430	154	35.8	276	64.2	281
Sept. 3	Goliad	875	347	39.7	528	60.3	540
Aug. 30	Hallettsville	1,150	250	21.8	900	78.2	903
Aug. 30	Hallettsville	230	93	40.4	137	59.6	137
Sept. 24	Junction	383	254	66.3	129	33.7	129
Aug. 26	Kerrville	29	6	20.7	23	69.3	23
Sept. 3	Kerrville	17	5	29.4	12	70.6	12
Sept. 26	Lula	278	228	82.0	50	18.0	54
Aug. 23	Marshall	52	29	55.8	33	44.2	23
Aug. 10	Mineola	100	88	88.0	12	12.0	12
Aug. 10	Mineola	120	38	31.7	82	68.3	87
Oct. 2	Mineola	697	353	50.7	344	49.3	347
Aug. 23	Overton	148	35	23.7	113	76.3	113
Aug. 23	Overton	164	80	47.6	84	52.4	84
Aug. 10	Palestine	1,327	285	21.5	1,042	78.5	1,042
Sept. 4	Palestine	8	2	25.0	6	75.0	6
Sept. 24	Roosevelt	88	25	28.4	63	71.6	69
Aug. 15	San Antonio	83	53	63.9	30	36.1	33
Aug. 16	Taylor	79	35	45.6	44	54.4	44
Sept. 19	Terrell	88	35	40.0	53	60.0	53
Aug. 9	Trinity	900	347	38.6	553	61.7	553
Aug. 9	Trinity	887	393	44.3	494	55.7	494
Aug. 30	Trinity	614	225	36.6	389	63.4	390
Aug. 30	Trinity	240	124	50.2	116	49.8	116
June 16	Victoria	980	116	13.7	864	86.3	864
June 23-28	Victoria	3,496	518	14.8	2,978	85.2	2,978
July 5-9	Victoria	1,405	355	25.3	1,050	74.6	1,050
July 18-20	Victoria	679	197	29.0	482	71.0	494
July 22	Victoria	302	215	71.2	87	28.8	87
Sept. 1	Victoria	1,142	129	11.3	1,013	88.7	1,026
July 25	Waco	737	480	65.1	257	34.9	259
Aug. 17	Waco	170	131	77.0	39	23.0	39
Aug. 28	Waco	742	431	58.1	311	41.9	311
Aug. 29	Waco	1,300	711	54.7	589	45.3	591
Aug. 29	Waco	785	477	60.8	308	39.2	308
Oct. 12	Waco	1,284	1,032	80.4	252	19.6	253
Total		36,354	14,301	39.3	22,053	60.7	22,169

From Table XVI A, hanging, dried bolls, it appears that three-fourths of the number examined contained no weevil stage. In this case there were found 1.227 weevil stages for each boll which was found to contain any. The percentage containing some stage shows an exceedingly wide variation between the 1.3 per cent for San Antonio, where the infestation was slight, and the 83 per cent at Waco on September 20, where the infestation was very heavy. It seems that the presence or absence of a weevil stage has little, if anything, to do with the retention by the plant of a portion of its surplus fruit, but that the abundance of weevils in proportion to their food supply may be largely responsible for the variations which appear in the percentage of these dried, hanging bolls which contain some weevil stage.

In Table XVI B, among the hanging dried squares, nearly 59 per cent of these examined contained some weevil stage. In this case there were found an average of but 1.01 stages per square. The percentage containing weevil stages varies somewhat, as it did in the case of dried bolls, but the variations are not exactly parallel. One reason for this apparent lack of agreement may be found in the fact that weevils show considerable preference for squares, and therefore attack them to a much larger extent than they do the small bolls. Among the bolls an average of 24.6 per cent contained some stage of the weevil, while among the dried squares there were 58.8 per cent.

In Table XVI C, fallen bolls, it appears that an average of only about 18 per cent contained some weevil stage. In this case there were found 1.106 weevil stages for each boll found to contain any. Examinations in three localities failed to reveal any weevil stage in a total of 380 bolls. Two of these examinations were made at Victoria in June before weevils had become sufficiently abundant to attack bolls to any extent. The third case was at San Antonio, where, as is indicated by observations in the other classes of forms, the infestation was comparatively light. It is probable, however, that a more extensive examination would have revealed some weevil stages in fallen bolls at San Antonio.

In Table XVI D, fallen squares, it is shown that slightly over 60 per cent contained some weevil stage. In this very large series of examinations there were but 1.05 stages for each square containing any. As would naturally be expected, there is not quite so wide a range between the extremes in the percentage of total squares which were found to contain a weevil stage as in other classes of forms. The importance of fallen squares, as compared with other classes of infested fruit, is shown by the fact that, in the 36,354 fallen squares examined, were found 22,169 weevil stages; whereas, in the 40,166 forms in the other three classes for Texas, there were but 11,666 weevil stages. While 60.7 per cent of the fallen squares were found to contain some stage of the weevil, an average of the three other classes of forms showed stages in but 26 per cent. The special significance of these comparisons, from the standpoint of natural control of the weevil, may be appreciated when it is considered that the total mortality in fallen squares is much greater than in any other class of forms.

This may be more clearly understood if we consider a concrete illustration based upon the actual average percentages shown in Table III. In addition to the percentage of weevils found dead at the time of examination, it is reasonable to assume that had the stages been left in the undisturbed forms until all surviving weevils might have emerged, there would have been an increase in mortality fully equal to one-half of the percentage shown by the examinations. Based upon this mortality, a hypothetical illustration shows in a striking way the influence which the class of form may have upon the proportion of weevil stages reaching maturity therein.

TABLE XVII.—*Illustration of effect of natural control, as found, upon weevil development in each class of forms.*

Class of forms.	Number of weevil stages starting therein.	Number dying as by proportions found at examinations given herewith.	Additional number likely still to die before emergence.	Number of adult weevils emerging.
Dried, hanging bolls	100	30	15	55
Dried, hanging squares	100	53	27	20
Fallen bolls	100	33	17	50
Total for 3 classes above	300	116	59	125
Fallen squares	300	180	90	30

From this illustration it may be seen that the chances for a weevil to reach maturity are greatest in hanging bolls, second in fallen bolls, third in hanging squares, and least among fallen squares. Starting with three hundred stages, distributed equally among the first three classes of forms, between 40 and 45 per cent may be expected to become adult, while an equal number of stages in fallen squares may probably yield not more than 10 per cent of adults.

It is fortunate that under normal conditions a large majority of weevil stages develop in squares which fall to the ground. Because of this fact it is possible for the most important factors of natural control to exert their greatest influence in checking the multiplication of the weevils. Without the large degree of natural control, such as has been shown to have existed in 1906, the profitable production of cotton would, apparently, not be possible. Understanding something of the influence of these factors, as we now do, we can appreciate in some measure our indebtedness to them for making it possible to continue the culture of cotton throughout the area which still, in spite of the damage actually done by the weevil, produces more than one-third of the annual crop in the United States. We can appreciate also the importance of following such methods in the culture of cotton as are found to promote in the greatest degree the efficiency of any factor in the natural control of the weevil.

SUMMARY AND CONCLUSIONS.

If there be a fair amount of moisture in the soil up to the time squares begin to form, and there then ensues a period of from four to six weeks of hot dry weather, with mean average temperatures ranging from 75 to 85 degrees F., it may be expected that the weevils, though abundant theretofore, may be so effectively checked as to do little injury to the crop of that season.

An entire season of extreme drought, even without exceptionally high temperatures, will greatly reduce the number of weevils, but the crop will be small because of the continued lack of moisture. This condition may show little benefit from weevil control during that season, but will greatly favor the production of a large crop, if weather conditions be favorable, during the following season. The difference in effect of a drought during squaring season alone and during the entire season lies in the widely different effect which those conditions exert upon the number of weevils developed in the fall, upon the food supply available to the weevils until time for them to enter hibernation, and upon the shelter obtainable by the weevils during winter. In the former case many weevils may survive, in the latter few weevils will survive to attack the succeeding crop.

Winter conditions of unusual severity with frequent low temperatures and much rainfall have a beneficial effect by reducing the number of weevils surviving hibernation and by preventing the survival of old cotton roots.

By cultural practices it is possible to secure regularly as great reduction in weevil injury during the following season as occurs occasionally after winters of extreme severity.

Defoliation of cotton by the cotton leaf worms, if thorough and repeated, may be a very important factor in reducing the number of weevils in a field which may enter hibernation, or which are likely to survive. The planter can usually secure regularly much of the good effect of irregular leaf worm defoliations by destroying the cotton stalks early in the fall.

Fallen forms contain fully 70 per cent of the weevil stages developing in a field. These stages are exposed to the most effective action of heat and of ant attack. Only in case of the fallen forms is it possible to vary cultural practice so as to increase the effectiveness of these factors. The mortality occurring in fallen forms is fully four times as effective in controlling the weevil as is that in hanging forms.

Less than one-half of all the weevil stages were still alive when found. If these had been allowed to remain undisturbed, under the continued influence of the three factors of natural control studied, it is very probable that the total mortality resulting would finally have amounted to fully 70 per cent. From 10 to 15 per cent of mortality occurred from other causes than those given in the tables.

All factors of natural control seem to operate more effectively against weevil stages in squares than against those in bolls. Ants and heat or drying are the most important factors in each class. In bolls about two-thirds of the stages found were alive, while in squares but two-fifths were living.

The data used in this bulletin include examinations in twenty-eight localities, in several fields in each locality, and in seventeen places examinations upon from two to nine dates between June 15 and October 15, 1906. More than 86,000 forms were examined and 39,000 weevil stages were found.

Nearly all of the eleven localities having an average total mortality above the average for the twenty-eight localities examined are situated south of the center of cotton production in Texas.

Ants of the species *Solenopsis geminata* are more important in the summer control of the weevil than are heat and parasites combined.

The effectiveness of heat from sunshine is largely influenced by spacing of plants, which should be wide for best results, and by the coincident dryness of soil or atmosphere. The mortality from heat in two groups of localities having almost identical mean maximum temperatures varies as widely as between 7 and 27 per cent. Exact reasons for this great difference are not apparent. Average climatic variations do not appear to produce a corresponding variation in the average mortality of weevil stages.

Ants seem to enter only forms containing living stages of the weevil. Variations in mortality from ant attack may be due to varying abundance of the ants in different fields or localities. Their activity is evidently influenced by climatic conditions and may also be affected somewhat by cultural conditions.

All parasites attacking the weevil have other hosts. Parasite attack is much greater in hanging than it is in fallen forms. The abundance of parasites seems to depend largely upon the proximity of some other plant than cotton in which their usual hosts abound. Their attack upon the boll weevil is a promising adaptation to a new host and may increase in effectiveness.

Climatic and cultural conditions seem to have been less influential in producing the three highest percentages of mortality than were the ants alone.

The highest mortality from heat or drying was found at Corpus Christi, Tex., in coincidence with comparatively low average maximum and average mean temperatures, but after an exceptional drought extending over some eight or ten weeks. This occurred also in a well-tilled field where not more than one-half of the ground was shaded.

The proportion of clear to cloudy days and the relative rainfall seem to influence in considerable degree the effectiveness of high temperatures.

Comparison of mortality records in localities infested for not more than two years with those in localities infested for from three to ten years shows a total mortality averaging about 10 per cent greater in the section longer infested. This increase was due principally to the greater effectiveness of heat and parasites, while in the recently infested area ants were exceptionally effective. The principal reasons for these differences were probably the more moist climate and the more abundant ant distribution in the recently infested area.

Nearly 70 per cent of all mortality found from heat or drying occurred during the larval stage. The ratio of mortality percentages in each weevil stage from heat is: Adult 1, pupa 3, larva 9. An early shedding of infested forms is very desirable.

Whatever spacing may have been found advisable where weevils were not present, these records prove the general soundness of the recommendation for increasing the space allowed each plant where the weevils are abundant. Central Texas shows the high average mortality of 21.8 per cent by parasites in hanging squares, 8.4 per cent in hanging bolls, and 5.7 per cent in fallen squares. Owing to the small number of observations made in southwestern Texas, western Louisiana should really be ranked first, with 39.4 in average percentage of total mortality among hanging dried bolls, while central Texas is second, with 28.8 per cent. Among hanging dried squares central Texas stands first, with 65.4, and western Louisiana second, with 61.3 per cent. Among fallen bolls eastern Texas ranks first, with 50 per cent mortality, and western Louisiana second, with 33.4 per cent. In eastern Texas alone did the number of fallen bolls examined exceed the number of fallen squares. Among fallen squares southern Texas has a long lead in total mortality, with 70.7 per cent, as compared with central Texas, with 50 per cent. The high percentage found in this class is based upon much the largest series of examinations made for any class in any section, and the figures are therefore exceptionally reliable and significant.

In degree of benefit from natural control, the six groups of localities rank as follows in average percentage of total mortality

	Per cent.
Southern Texas	62.6
Central Texas	45.5
Western Louisiana	43.2
Eastern Texas	41.4
Northeastern Texas	31.9
Southwestern Texas	26.0

In examination of about 11,000 fallen forms collected between August 10 and August 31, 1905, 25 per cent were squares and 75 per cent were small bolls. The proportion between these forms varies greatly with the stage of growth in each field. In the examination of 62,593 fallen forms collected between June 15 and October 15, 1906, 64 per cent were squares and 36 per cent bolls. Among 24,363 hanging forms examined in 1906, 28.6 per cent were squares and 71.4 per cent bolls.

In a test of the effect of hand picking of infested fallen forms in 1905, it is probable that between 34,000 and 42,500 adult weevils were thereby prevented from emerging upon an area of 8 acres. In spite of this large destruction of weevils, the increased yield of seed cotton upon the test area averaged only about 50 pounds per acre as compared with a check area of similar size. This shows the tremendous importance and effectiveness of natural control, which frequently produces much greater increases in yield than 50 pounds of seed cotton per acre.

In the examination of 11,000 forms from Louisiana in 1906, only 44 per cent were found to contain a weevil stage. The balance of 56 per cent included many which had been injured by feeding of the weevils. Among the bolls 30 per cent and among squares 60 per cent contained some stage of a weevil. Probably few of the remainder of the squares had escaped some form of weevil attack, but a large proportion of the 70 per cent of bolls perished without any injury by the boll weevil.

In examinations of forms collected in Texas in 1906 among more than 14,000 dried, hanging bolls, hardly 25 per cent showed any stage of the weevil; among over 20,000 fallen bolls only 18 per cent had any stage; among 5,600 hanging dried squares nearly 60 per cent and among more than 36,000 fallen squares slightly over 60 per cent contained a weevil stage. Practically two-thirds of all weevil stages found in Texas were in the fallen squares.

The proportion among 100 weevil stages starting in each one of the four classes of forms which may be reasonably expected to reach maturity and emerge is as follows: Hanging dried bolls, 55; fallen bolls, 50; hanging dried squares, 20; fallen squares, 10.

Evidently we are indebted in a very large degree to the effectiveness of natural control for the possibility of continuing cotton production. Such cultural methods should be followed as shall exert the strongest influence upon hastening the maturity and increasing the yield of the crop. In addition to this, such cultural methods should be followed as will promote the highest efficiency of the factors in this natural control of the Mexican cotton boll weevil.

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DIV. INSECTS.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 75, Part I.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

PRODUCTION AND CARE OF EXTRACTED HONEY.

BY

E. F. PHILLIPS, Ph. D.,
In Charge of Apiculture, Bureau of Entomology.

METHODS OF HONEY TESTING FOR BEE KEEPERS.

BY

C. A. BROWNE, Ph. D.,
Chief, Sugar Laboratory, Bureau of Chemistry.

Issued December 19, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

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U. S. D. A., B. E. Bul. 75, Part I. A., December 19, 1907.

MISCELLANEOUS PAPERS ON APICULTURE.

PRODUCTION AND CARE OF EXTRACTED HONEY

By E. F. Phillips, Ph. D.,
In Charge of Apiculture.

INTRODUCTION.

Since the invention of the centrifugal honey extractor, in 1865, and its introduction into America, a constantly increasing proportion of the honey of the United States has been put on the market as extracted. Formerly honey was rendered free from comb by mashing full combs of honey and straining the liquid through a cloth. This is "strained honey," but the same name still clings, in some quarters, to the article removed from the comb by centrifugal force. The production of extracted honey requires much less labor on the part of the bee keeper than does the production of comb honey, and it has several advantages over the latter. The principal reason why extracted honey is more generally produced in the United States than formerly may probably be found in the increasing demand for honey for baking and confectionery purposes; considerably more than half of the honey put on the markets is used in this way.

The ease with which extracted honey may be adulterated has, however, made the general public sceptical as to its use for table purposes; glucose, cane sugar, invert sugar, and other adulterants have been very extensively used, and are still used to some extent. However, the passage of the food and drugs act of June 30, 1906, and the recent work of this Department in the inspection of the honey market have resulted in much good, and persons who have openly adulterated extracted honey in the past are now generally obeying the law. While there is still some cause for complaint, the percentage of adulteration must gradually decrease. The effect of pure-food agitation can not but result in great good to the honest honey producer and bottler.

The chemical detection of honey adulteration has been made more certain by the recent investigations of Dr. C. A. Browne, of the Bureau of Chemistry, and because of the improved methods advocated by him the detection of infringements of pure-food laws will be easier in the future. For a discussion of this work the reader is referred to Bulletin No. 110 of the Bureau of Chemistry, entitled "Chemical Analysis and Composition of American Honeys."

Some of the common practices of bee keepers are, however, open to serious question, and it is primarily to call attention to these that the present paper is presented. It is possible to treat pure high-grade extracted honey so that on chemical examination it would be condemned or called in question. In the past there has been some trouble in cases where chemists have declared honeys, to which nothing has been added, to be adulterated; part of the fault possibly lies with the use of poor methods by chemists, but not all of it. If a bee keeper treats pure honey so that its chemical composition is changed, it is no longer honey, and should not be sold for such. Several of the most widely circulated text-books on apiculture advocate very questionable practices.

There are several text-books giving detailed information as to the production and care of extracted honey. It is not the purpose of this paper to replace these, but to point out the main principles to be observed, and especially to call attention to a few points which do not seem to be understood by the majority of honey producers. Many details which are apparently unnecessary in most cases are omitted, since the writer believes that each bee keeper must find out many minor details in his own experience, and less important phases of the work may better be learned from other sources.

THE ADVANTAGES OF THE PRODUCTION OF EXTRACTED HONEY.

It is not the purpose of this paper to advocate the production of extracted honey as preferable to that of comb honey, nor would it be at all desirable to have the production of fancy comb honey diminished. For the benefit of the honey market, however, it could not result in anything but good were the poorer grades of comb honey to be sold as extracted. The discolored ("travel-stained") and irregularly or partially capped comb honey found on so many markets is a poor advertisement for the the bee keeper who tries to produce a fancy article.

The production of extracted honey means considerably less labor for the bee keeper and also less work of certain kinds for the bees, for it is not necessary for the latter to secrete so much wax. Since it takes several pounds of honey under most conditions to produce 1 pound of wax, the surplus per colony is greater with extracted honey than with comb, but this is compensated by the fact that comb honey of equal grade universally sells at a higher price.

In the production of extracted honey it is much easier to control swarming, since the brood chamber is not contracted so much and the queen has an opportunity to work to her maximum capacity. On the other hand, the colony is usually stronger, with more field bees; this is probably a large factor in the increased amount of surplus obtained from a colony run for extracted honey.

When the honey flow begins, the bees can at once commence to store honey in extracting combs, provided the bee keeper is careful to put them on in time, but in comb honey production it is first necessary for the bees to secrete a considerable quantity of wax before there is room for honey in the surplus boxes or sections and honey is consequently stored in the brood chamber; if much honey is stored here, the queen is cramped for room to lay. The novice at extracted honey production should be careful not to extract so much of the honey in the hive that the bees will not have enough to live on. This is a very common error until the bee keeper is taught by experience how much to extract. It is better to extract too little than too much.

METHOD OF PRODUCING EXTRACTED HONEY.

THE HIVE.

The hive used for extracted honey production should be at least as large as 10 frames. However strongly the advocates of 8-frame hives or even smaller ones may urge the advantage of a contracted brood chamber in order to crowd the surplus honey into the upper stories, certainly these small hives have little place in the production of extracted honey. The queen should have at least 10 frames for brood rearing, if the bee keeper is to expect the maximum results. The use of large hives is upheld by the practices of the largest and best extracted-honey producers of the United States, and the small hives have small sale among extensive producers.

BROOD MANIPULATION.

In the production of honey, either comb or extracted, it must be remembered that if the honey flow is short, only those bees which are fully developed at the beginning of the flow are of any value in honey gathering. The amount of brood reared normally increases at the beginning of a honey flow, especially with Italian bees, but this brood is rarely of much use in producing honey gatherers. In many cases it may be desirable to retard brood rearing at the beginning of the flow by caging the queen or even by removing frames of brood. On the other hand, it is advisable to see to it that brood rearing is extensive for several weeks before a honey flow is expected. This may be brought about by stimulative feeding and by the cautious spreading of brood in the colony. This procedure usually pays well. A careful study of locality conditions is necessary before planning operations of this nature.

TIERING.

Before, or just at the time of the beginning of the honey flow, a hive body exactly similar to the brood chamber should be given to the colony. Many bee keepers put only 8 or 9 frames in a 10-frame hive body used as a surplus chamber so that the bees will build thick combs. Since in uncapping the honey the comb is cut down to about normal thickness, this gives a place for the immediate storing of surplus honey and at the same time permits the bees to secrete some wax. The physiology of wax secretion is very imperfectly understood, but probably wax is always secreted, to a greater or less extent, during a heavy honey flow, and by spacing wide this wax is saved to the bee keeper.

As the frames of the second hive body become filled, the honey may either be extracted at once and the frames returned to be refilled or an additional hive body full of frames may be put directly over the brood chamber and below the first surplus body. Bees go unwillingly through combs of sealed honey to empty combs higher up, but the new combs should be between the first two hive bodies. The reasons for tiering up hives rather than immediate extraction will be discussed under the heading of “ Ripening honey.” This operation may be continued as long as room is required, and the bees should never be unduly cramped for room. On the other hand, it is usually not desirable to give too much room at one time for surplus, for the honey may be spread over all the combs and, as a result, the cells capped when not drawn out well. It is sometimes desirable in the early part of the season to give only two or three frames for surplus at first, gradually increasing the number as necessity arises. This is particularly the case in uncertain weather or in a light honey flow.

When the surplus combs are first put on, one or two frames containing brood with the adhering bees are frequently placed in the second story and empty frames put in their place in the brood chamber. By this means the bees at once get into the second story, and this manipulation is a very desirable thing where brood frames are used for extracting. When only clean combs are used, these brood frames may be returned to the brood chamber in a day or two, for by that time they are usually no longer needed. Of course care must be taken not to lift the queen to the second story above the perforated zinc.

Some bee keepers prefer the use of shallow extracting combs of a depth about half that of the ordinary brood frame. The advantage of such a size of frame is, briefly, the possibility of putting on a smaller amount of storing room at one time, in consequence of which the honey is capped over in a better manner. In other words, the forcing methods of comb honey production are carried over into the production of extracted honey. It would certainly be unwise to recommend or condemn this system in general, for its use should be governed by local conditions of the honey flow. In this case, as in many others, the maximum results may not be expected without a careful study of local conditions. Bee keepers talk a great deal about " locality differences," and, as generally used, the term " locality " is only an excuse for a lack of information as to the true cause of various observed facts. It is nevertheless most true that there are scores of local differences which are great enough to bring success or failure, according as they are studied or neglected.

PERFORATED ZINC.

The use of a perforated zinc queen-excluding board between the brood chamber and the surplus bodies is gaining in popularity. Without this zinc the queen is likely to go into the second story, or even higher, particularly toward the close of the season. Some bee keepers prefer to use combs for extracting which have never been used for brood, and if this plan is followed the perforated zinc is absolutely necessary. Honey extracted from dark combs which have been used for brood is darker in color as a rule than that produced in combs which have never contained brood. This is doubtless due to the fact that a certain amount of the larval skins and larval excreta which are packed at the bottom of brood cells becomes dissolved in the honey. These deposits in the cells are usually spoken of as " cocoons," but certainly only a small part is really the silk of the cocoon. If this really were merely a cocoon, no possible objection could be made to the use of brood combs for extracting. It would probably do little good to advocate the universal use of only such combs as had not been used for brood rearing in the production of extracted honey, but a strict regard for cleanliness would most assuredly demand it.

REMOVING HONEY FROM THE HIVE.

Honey should not be taken from the hive until fully " ripened." When the time comes to extract, the frames should be lifted from the hive and the adhering bees shaken or brushed off. They may be brushed off with a regular bee brush, many styles of which are manufactured, or a bunch of grass or weeds will usually answer as well. The only advantage of a regular brush is that it is always ready for use.

If the honey flow is over or the bees are hard to manipulate on account of their stinging, a bee escape is desirable. The escape is so arranged that the bees can pass down to the story below with comparative ease but can not get back. Within a few hours the upper story is cleared of bees and the frames of honey may be removed easily. If the queen is in the upper story, however, as she may be if no perforated zinc is used, or as she occasionally is anyhow, the bees will not desert the brood, and there will still be bees on the combs. Escapes may be put on by quickly lifting the upper story and inserting the board in the evening, and by the next morning the upper story will usually be entirely clear of bees.

After the combs are removed from the hive, they should be kept covered so that the bees in the air will not begin to rob. The manner of carrying them to the extracting room will depend on the number of combs to be carried and the arrangement of the apiary. Tin buckets holding five combs at a time may be used; an extra hive body is often fixed with a handle and cloth cover, or the entire hive body may be carried in on a cart or otherwise if it is free from bees.

THE EXTRACTING ROOM.

The place where the honey is extracted should be so arranged that no bees can enter it when attracted by the odor of the honey. The windows should be so built that if some bees do enter they can easily get out through bee escapes or cones so constructed that no other bees will be able to find the opening. Bee escapes may be used, but usually a better plan is to have the windows covered with wire cloth tacked on the outside, the wire cloth extending above the window about 6 inches and held away from the side of the house by quarter-inch strips. Bees almost always crawl upward and they will crawl up the netting and out through the top openings, but other bees will not try to get in that way. A screen so arranged will allow a very large number of bees to escape very quickly. That the extracting room be "bee tight" is practically the only absolute requirement. Honey should never be extracted in the open air except during a heavy honey flow, when bees are not inclined to rob. Where several apiaries are under the management of one man, it is sometimes desirable to make a portable extracting house on wheels so that it may be taken from place to place.

UNCAPPING HONEY.

The honey, before it is extracted, must be uncapped, and this should be done with a long knife which is kept *sharp*, *clean*, and *warm*. There are several types of uncapping knives. If a considerable amount of honey is to be extracted, it is desirable to have two or more knives for each operator so that one may be heated in hot water as the other is used.

As the cappings of wax are cut off some honey flows out, and consequently the uncapping should be done over a regular uncapping box or can. This may be easily made at home to suit individual requirements, or any one of the several types offered for sale may be used. The boxes are either made of metal or lined with tin to prevent the leakage of honey, and about halfway up is a heavy wire netting to catch the wax cappings and allow the honey to drain off into the lower compartment. This honey may later be added to what comes from the extractor.

THE EXTRACTOR.

The extractor consists of two or more baskets into which the combs of honey are placed and which are revolved inside or with a can. The rotation drives out the honey by centrifugal force, leaving the cells empty, provided the uncapping has been thoroughly done. While the extractor is a very simple machine in principle, its construction has been the subject of much experimenting, and various types have been made. The best type of extractor has been found to be one in which the surrounding can is stationary and the baskets are arranged to revolve inside it. Some types are now made so that the baskets may be turned and both sides of a comb emptied without removing the frame from the basket of the extractor. The more elaborate types, holding several frames and driven by power, may be found described in catalogues of the dealers in bee keepers' supplies.

The extracted honey flies to the side of the can and then runs to the bottom of the machine; it then runs off through an opening at the bottom into a vessel or tank for the purpose. As it leaves the extractor it should be run through a cheese cloth to remove any particles of wax or other foreign substance which may have got into it. The care of the honey will be described later.

Empty combs wet with honey should not be returned to the bees while extracting is in progress, for fear of inciting robbing. They may be piled up in the extracting room until the work is almost completed and, if any additional honey flow is expected, they may then be returned. If to be kept until the next year, they should be given to the bees for a short time to be cleaned of honey, and then removed and put away so that wax moths will not destroy them. The greatest essential in the production of the maximum amount of extracted honey is an adequate number of surplus combs.

THE RIPENING OF HONEY.

When nectar is gathered from flowers by the worker bees, the amount of water contained in it is very high. It is generally supposed that, by the time bees reach the hive to deposit the nectar in the cells, part of this water has been removed; at any rate, during the process of ripening, the amount of water is very much reduced, until, in thoroughly ripened honey, it will not exceed 25 per cent and is generally not more than 20 per cent. Some very ripe honeys will have as little as 12 per cent of water in them. If more than 25 per cent of water remains in the honey at the time of extraction, it will probably ferment. The ripening of honey consists not only of the evaporation of the surplus water of the nectar, but especially of the transformation of the sugars of the nectar into the levulose and dextrose of honey. Unripe honeys contain a larger proportion of sucrose or cane sugar, and it is probable that the longer the honey remains in the hive the less of sucrose will be found in the honey. While honeys vary all the way from zero to 8 or 10 per cent in their sucrose content, the purest honeys are those which contain the least. The official honey standard of the Association of Official Agricultural Chemists allows 8 per cent of sucrose in honey.

It is the policy of most bee keepers to allow this ripening to take place in the hive by waiting until the honey is almost all or entirely capped, and this is undoubtedly the preferable method. It is a matter of common observation that honey which remains in the hive for a long time has a better "body" and has more of the characteristic honey aroma. By ripening in the hive honey gets its characteristic flavor to a greater extent than is possible in evaporation outside the hive.

Several machines have been devised for the artificial ripening of honey which has been extracted "green," that is, with too great a water content. The principle on which all of these are constructed is the application of heat, not to exceed 160° F., for a sufficient time to reduce the amount of water present to about 20 per cent. Either sun heat or artificial heat may be used. In the western part of the United States honey may be, and usually is, extracted before it is all capped, because it is the general practice of bee keepers to run the honey directly from the extractor to large tanks, sometimes holding several tons, out in the open, covered with porous cloth tightly tied down to exclude bees. Many of these tanks are contracted at the top, leaving only a comparatively small opening. On account of the extreme dryness of the atmosphere and total lack of rain during the dry season, this partial evaporation outside of the hive takes place very rapidly.

The advocates of ripening outside of the hive argue that, if honey is extracted before all the water is removed from it, the bees have less to do inside the hive and can devote almost all their time to gathering nectar in the field. This obviously would result in an increased amount of nectar and, consequently, provided the forage will produce it, in an increased amount of honey. They argue that it is impossible to detect any difference between honey ripened inside the hive and that ripened outside, as far as flavor is concerned, but this is a point on which many other bee keepers and experts in honey tasting do not agree with them. It must be admitted that, for general sale, the delicate aromas of well-ripened honey are not necessary, since the purchasing public is, as a rule, not educated on this point; but it certainly pays to produce the very best article possible for the further education of the trade, and, therefore, a thorough ripening inside the hive is very much preferable. To insure this, it is better to tier up the hives rather than extract as soon as a hive body is full.

On all honeys, after extracting, if allowed to stand in a vessel, a scum will rise to the top, made up of impurities, such as wax, brood, dead bees, and particles of dirt which may get into it. This is particularly the case with honeys which are extracted when not thoroughly ripened. In all cases honey should be strained as it leaves the extractor and subsequently skimmed until no further impurities come to the top. It is frequently the practice to draw honey from the bottom of the tank in which the honey is stored through a "honey gate," so that the impurities do not get into the smaller receptacles in which the honey is to be packed.

The thorough ripening of honey can not be too strongly recommended. Honey attracts moisture, and there is always a tendency for a very thin layer to form on the top in which the water content is very high. In such a film the amount of sugar is low, the acetic-acid-forming bacteria can grow rapidly, and the honey becomes sour. In thoroughly ripened honey it is very probable that a film of thinner honey is always present, but in such a case the sugar content is so high that the bacteria can not grow.

It is desirable that honeys from different sources be kept separate as far as possible if the product is to be used for the bottling trade. This can be done only by extracting at the close of each honey flow. While it is probably impossible to get a honey from only one species of plant, except under the most unusual circumstances, at the same time honey may generally be removed at the close of each flow, so that the total quantity will have the characteristic flavor imparted by a single kind of flower.

THE GRANULATION OF HONEY.

Almost all honeys granulate or "candy" after a certain time, and may become solid. This phenomenon varies greatly with different honeys. For example, alfalfa honey produced in Colorado will often granulate solid within a few weeks from the time it is extracted, while the white-sage honey of southern California will often remain liquid and entirely clear of crystal for two years and sometimes longer, if properly put up. The reason for this difference in the time of granulation will be discussed under the heading of "Types of Honey." Honey from the same species of plant varies somewhat in this respect in different localities.

Formerly the general public was suspicious of granulated honey, in the belief that it contained cane sugar, but, fortunately, it is now generally understood that pure honeys will granulate in time, and this crystallization is generally considered as a test of purity. The education of the purchasing public has so far progressed that now some bee keepers prefer to sell their honey in a solid granulated condition, it being cut up into bricks and wrapped in oil paper.

In bottling honey, or in putting honey from any large receptacle into smaller ones, it is necessary to liquefy the entire quantity completely before the operation is begun. This may be done by immersing the receptacle in water which has been heated to 160 or 170° F., and letting it remain until the honey is all liquid and free from crystals. Honey should never be liquefied by direct application of heat, and it is extremely important that it should not reach a temperature of more than 160° F. It is well known to almost all bee keepers that honey heated to higher temperatures will become darker in color and lose flavor, and, consequently, they are generally very careful on this point. There is, however, a very much more important reason for avoiding high temepratures. When honey is heated to 180° F. and more, the higher alcohols which give honey its aroma are driven off and, more than that, a decomposition of certain of the sugars takes place; this is what gives the darker color to the honey. Of all the various substances used for the adulteration of honey the one most nearly resembling pure honey is invert sugar, of which Herzfelt's artificial honey is one of the best illustrations. In the detection of adulteration, one of the tests for the addition of invert sugar is based on the presence of decomposition products due to heat. These decomposition products in invert sugar are probably identical with the decomposition products in overheated honey; at any rate, honey which has been heated to more than 180° F. for any considerable time gives the test for invert sugar and would, therefore, be declared to be adulterated if this test were applied by a chemist. A bee keeper might argue that he was not infringing on the pure-food law in overheating his honey, since he had added nothing in the way of an adulterant. If, however, he changes the chemical composition of his honey by injudicious treatment it is no longer pure honey, and he has no right to sell it under that name.

It is very much safer to liquefy honey at a temperature of about 140° F. and thus avoid any danger of decomposition. If this lower temperature is used it is of course necessary to keep the honey at this temperature for a considerable time, but the safety of such a proceeding makes the extra time well worth while.

Two or three of the most widely circulated American text-books on bee keeping advocate the drawing off of the liquid portion of granulated honey, particularly in the case of honey which was not thoroughly ripened before it was extracted. The granulated portion is then allowed to liquefy and is recommended as a very fine quality of honey. This practice is in no way permissible, as will be readily seen if the composition of honey is studied. Honey is made up of dextrose and levulose in about equal quantities, sucrose, a certain amount of ash, and water. In granulation, the dextrose crystallizes readily and the levulose probably does not granulate at all. If, then, the liquid portion, consisting largely of levulose, sucrose, and water, is removed by draining or by pressure, the remaining portion is not honey, but dextrose. However fine the flavor of such a compound may be, it is not honey and can not truthfully be sold as such.

Since honey separates into its component parts in granulation, it is very necessary that all the honey in the receptacle be liquefied and thoroughly mixed before any portion is removed from it for bottling or canning. If, for example, honey is in a 60-pound can and is to be transferred to 1-pound bottles, it is necessary that the entire 60 pounds be liquefied and mixed before any is poured out into bottles, in order that all the bottles may contain honey according to the legal standard. Unless this is done, some of the bottles will contain a high percentage of dextrose and will granulate rapidly, while others will contain a preponderance of levulose and will not granulate for a long time. Unless this mixing is done thoroughly, none of the bottles will contain absolutely pure honey. In order to protect himself, the bee keeper must be very careful on this point. Some bee keepers prefer to pour the honey cold into the bottles and heat it afterwards before sealing. As a matter of convenience this has many points in its favor, but in view of the separation into component parts which may take place it is a bad practice. The honey should first be heated and liquefied completely, especially if honeys from several species of flowers are to be blended.

As previously stated, there has existed and possibly still exists a popular idea that granulation indicates adulteration by the addition of cane sugar. This is of course untrue, since pure honeys do granulate solid. Many bee keepers in combating this idea have stated that this very granulation is a test of the purity of the honey. This statement, so frequently made, is equally untrue, since invert sugar, one of the adulterants sometimes used, will also crystallize solid as rapidly as do most honeys.

Age seems to affect honey greatly. Repeated granulation and liquefaction, as the temperature varies year after year, in some way affects the chemical composition of the honey, changing the product so that it may not have the composition that it had at first. Some honey thirty-five years old, submitted to this Department, was found to contain too much sucrose. A sample of the same honey had previously been analyzed by two official chemists and declared to be adulterated; but the history of the sample precluded this possibility. The honey had apparently changed greatly with age in appearance as well as in composition.

Some bee keepers make a practice of adding a very small amount of glycerin to the honey to prevent granulation. This should not be done, for it is adulterating the honey. Some have argued that, since glycerin costs so much more than honey, they are not adulterating in that they are not adding something cheaper to the honey to increase their profit. According to pure-food laws, however, nothing can be added to honey unless the addition is specifically stated, and the addition of even a small amount of glycerin is, in the eyes of the law, as great an offense as the addition of glucose.

HEATING HONEY FOR THE DESTRUCTION OF THE BACTERIA OF DISEASE.

The only condition under which honey should be heated to a higher temperature than 160° F. is in the case of honey which has been extracted from a colony containing foul brood. In order to kill the bacteria of either of the brood diseases, it is desirable to dilute the honey by adding an equal amount of water and then raise the temperature to the boiling point and keep it there, allowing the mixture to boil vigorously for at least thirty minutes; in order that no risk may be run, it is better to make this one hour. Honey which is so treated is changed chemically and is no longer pure honey, but it makes a good sirup for feeding to bees and is the best way of using honey from an infected source. Too much care can not be exercised in bringing this to the proper temperature, and it must be remembered that the resulting product is not honey, but a sirup, the chemical composition of which is quite unlike that of pure honey.

PACKING OF EXTRACTED HONEY.

If honey tends to granulate rapidly, it will save much trouble in liquefying to put it into the receptacle in which it is to be sold as soon after extraction as possible. There will then be no difficulty from the various ingredients becoming separated. To preserve the delicate aromas it is desirable that honey be sealed as soon as possible.

When honey is put up in less than 3-pound packages it is generally bottled. A bottle makes a much more attractive package than a tin can and shows off the contents. There is no doubt of the fact that honey sells largely on its appearance, and too much care can not be exercised in packing and labelling so as to make the package attractive to the purchaser. In cases where a bee keeper sells directly to a local trade he may educate his customers to judge his honeys by their flavor, in which event it is immaterial what kind of package is used.

and honey may even be run out from a large can into a vessel furnished by the customer when the honey is delivered. It is too often the case, however, that bee keepers put up their honey in such poor, unsightly packages that they can get only a low price for their goods.

If honey is put up in more than 3-pound packages, tin cans are generally used and the most common receptacle is a square can holding 5 gallons (60 pounds). Two of these are usually boxed together for shipment. Square and round cans of various types are often used for smaller quantities. Barrels are preferred by some for large shipments for the baking and confectionery trade, but their use can not always be advised. Before honey is put into it, a barrel must be thoroughly dry, and tight when dry, because of the fact that honey takes up a certain amount of moisture, and if, when the honey is put into it, the barrel is damp, the honey will absorb the moisture, causing the barrel to leak. Barrels also absorb a certain amount of honey. In dry climates particularly barrels should be used with caution.

When honey is packed in bottles, it is desirable that granulation be retarded, since a bottle of partially granulated honey is not attractive. To aid in the retarding of granulation, the honey should be entirely liquefied and thoroughly mixed in a large can and run into the bottle warm. The bottle should be as full as possible and sealed hermetically while still warm. Granulation usually begins on the edges of the top line of the honey and spreads rapidly from these points. This is probably because some honey gets upon the sides and partially dries. It is therefore desirable that the honey fill the bottle clear to the cover to prevent this. It must also be free of bubbles. Bottles may be hermetically sealed by using some style of clamp cover or by sealing a cork with a mixture of beeswax and resin. This mixture may be colored by the addition of a dye. Granulation may be considerably retarded by keeping the honey at a nearly uniform temperature. This should not be less than 65° F. and is much better at 90° to 100° F. While the honey is in the hands of the producer or bottler, it may be kept liquid for a long time in this way, but of course when sold it is generally subject to changes of temperature. Honey, either in the comb or extracted, should never be kept in a cool or damp place.

THE PRODUCTION OF "CANDIED" HONEY.

Honeys of the average type, relatively free from nonsugars, such as that made from alfalfa, soon granulate solid and are sometimes sold in bricks. Granulation may be hastened by changes of temperature and by stirring. If it is desired to have a can of honey granulate rapidly, it may be carried from a warm room out doors in winter and back again at intervals of a day or two for a couple of weeks. If this is accompanied with occasional stirring when granulation first begins, the whole can will soon be a solid cake. Honey may also be poured into smaller receptacles, such as waterproof pasteboard carriers or oyster pails, and allowed to crystallize in the package in which it is to be sold. If allowed to granulate solid in a large tin can, the tin may be cut away and the honey cut into bricks with fine wire in the way that prints of butter are sometimes prepared.

A market for "honey bricks" must generally be built up locally, for as yet the general public has not learned to look for honey in such shape. The cost of the package is less than that of bottles, and the granulated honey is by some considered superior for table use to liquid honey. Several bee keepers have used this method with success and claim that it gives great satisfaction to their customers.

HONEY TYPES.

It is well known that honeys from different plants vary considerably in taste, color, granulation, etc. The taste and color are given to honey by the plants from which the nectar is derived. Granulation may be considered as a property of all honeys, or rather of the dextrose contained in all of them, and, from a study of the chemical composition of many samples, it seems probable that all honeys would crystallize were it not for the fact that some of them contain an excess of either noncrystallizable levulose or dextrin, gums, and other nonsugars. The following table will make this point clear:

I. Normal honey (from nectaries of flowers).
    1. High purity (high in sugars, relatively low in dextrin, gums, and other nonsugars).
        A. Levulose type, e. g., mangrove, tupelo, sage.
        B. Average type.
            a. High in sucrose, e. g., alfalfa.
            b. Low in sucrose, e. g., buckwheat.
    2. Low purity (relatively high in dextrin, gums, and other nonsugars, e. g., basswood, sumac, poplar, oak, hickory, apple, most tree honey).
II. Abnormal honey (not from nectaries of flowers; generally high in dextrin, gums, and other nonsugars).
    1. Honeydew honey (from aphides and other insects).
    2. Coniferous honey (plant exudations not from nectaries).

Honeys containing approximately the same amount of levulose and dextrose and which are high in sugars (average type) granulate readily. Very few honeys have more dextrose than levulose. If, however, the levulose is considerably greater than the dextrose (levulose type), or if the nonsugars are relatively high (low purity and abnormal honeys), granulation is retarded. Some honeydew granulates rapidly, but no abnormal honeys of that type were included in the samples examined, consequently they are not included in the table.

The use of the terms "high" and "low" purity in this table must not be taken to indicate the comparative values of the various honeys. Low-purity honeys which have relatively more dextrin, gums, and other nonsugars are just as good honeys as those of the high-purity class. Abnormal honeys, however, are less desirable. The presence of the nonsugars in low-purity honeys may be due largely to a slight admixture of honeydew, since most honeys contain a trace of this. It must be remembered in considering this subject that practically no honey is from a single species of plant, and therefore they will vary considerably, according to the other nectars added to them as well as according to local soil and climatic conditions.

METHODS OF HONEY TESTING FOR BEE KEEPERS.[a]

By C. A. Browne, Ph. D.,
Chief, Sugar Laboratory, Bureau of Chemistry.

The most common forms of adulteration which are practiced at present in the sophistication of honey are the addition of commercial glucose, cane sugar, and invert sugar. The adulteration of honey by dilution with water is less commonly practiced; such addition is easily recognized by the increased fluidity of the honey, and there is, besides, the increased danger that the product will spoil through fermentation. It is often desirable, however, for the bee keeper to know the approximate percentage of moisture in his products in order to avoid the marketing of unripe honey which might exceed the limit for water allowed by the standards (25 per cent). The average water content of American honey, according to the average for 99 pure samples analyzed in the Bureau of Chemistry, is 17.59 per cent, so that there is above this a margin of more than 7 per cent in which the moisture of honeys may be allowed to fluctuate.

The accurate determination of moisture in honey in the chemical laboratory is a somewhat complicated process. A carefully weighed amount of the honey is evaporated at a temperature of about 160° F. in a vacuum chamber until no more moisture is given off, and the loss in weight during the interval is calculated as water. For the bee keeper such a method of determination is too involved and complicated; there is, however, a much simpler method by means of which the moisture content of a honey can be determined with ease and rapidity and with a fair degree of accuracy. This is by means of a specific gravity float or spindle. The liquefied honey is poured into a tall cylinder and immersed in hot water of 170° F. temperature. The honey is stirred with a thermometer and as soon as the temperature has reached 160° F. the spindle is lowered into the honey and allowed to come to rest. The point at which the surface of the honey cuts the graduation mark upon the spindle indicates the percentage of water in the honey.

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[a] This paper was prepared by Doctor Browne of the Bureau of Chemistry after the completion of his work on honey analysis. For greater detail the reader is referred to Bulletin 110 of the Bureau of Chemistry, entitled "Chemical Analysis and Composition of American Honeys." This bulletin may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. It can not be obtained from the Bureau of Entomology.—E. F. P.

For the accurate determination of glucose, cane sugar, and other adulterants, the bee keeper will usually be obliged to resort to the services of a chemist. This is especially true as regards cane sugar, as there is no simple test for this substance which can be applied by the ordinary layman. As regards glucose and added invert sugar, however, there are certain simple colorimetric tests which can be easily and quickly carried out.

A good colorimetric test for the presence of commercial glucose or starch sirup in honey is that of Beckmann, by means of a dilute solution of iodine in potassium iodide. One part of the honey to be examined is dissolved in one part by volume of water in a test tube and shaken up with a few drops of the iodine solution. If the honey solution remains a pale yellow, commercial glucose is probably absent; if the solution is colored a red or purple, however, the presence of glucose sirup is clearly indicated. In making this test it is always best to carry out a comparative test under similar conditions, using a honey of known purity and adding the same number of drops of iodine solution. In this manner a reliable comparison of colors can be secured.

The adulteration of honey with invert sugar sirup is being practiced to some extent in this country, though not as widely at present as in certain European countries. This sirup has in many respects the same composition as pure honey; it is deficient, however, in ash, albuminoids, and other constituents which occur in honey in small amounts. Through the action of the high temperature of boiling a small quantity of decomposition products of sugar is produced in this artificial honey which serves to distinguish it from pure honey unless the latter has been boiled for some time, in which case it also will contain decomposition products similar to those contained in the invert sugar sirup. An easy test for artificial invert sugar in honey is by means of a concentrated solution of aniline acetate. This reagent should be prepared freshly each time before using. Five cubic centimeters of chemically pure aniline are shaken up with 5 cubic centimeters of water and 2 cubic centimeters of glacial acetic acid added. The milky emulsion of aniline and water should clear up perfectly on addition of the acid. About 5 cubic centimeters of the honey to be tested are diluted in a test tube with an equal volume of water and a little of the aniline solution poured down the walls of the tube so as to form a thin layer upon the surface of the liquid. If artificial invert sugar is present, a red ring will form beneath this layer, and on gently agitating the tube the whole quantity of aniline acetate will be tinged this color, the depth of coloration depending upon the quantity of artificial invert sugar present in the mixture. Pure honeys which have not been spoiled by overheating do not give this reaction.

In carrying out the tests previously described only a very small outlay in apparatus will be required. The special spindles for determining the water content of honey and the other apparatus can be obtained from any manufacturer of chemical goods. Glass or metal cylinders for containing the honey while spindling will be needed, as also a collection of test tubes and racks. A small 50 cubic centimeter graduated cylinder will also be found useful for measuring out the volume of honey solutions and of reagents. All apparatus should be thoroughly cleaned and rinsed after using, as any contamination with impurities may affect the accuracy of the tests. The drugs specified may be purchased of any druggist.

O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 75.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

I. PRODUCTION AND CARE OF EXTRACTED HONEY.

By E. F. PHILLIPS, PH. D., *In Charge of Apiculture.*

METHODS OF HONEY TESTING FOR BEE KEEPERS.

By C. A. BROWNE, PH. D., *Chief, Sugar Laboratory, Bureau of Chemistry.*

II. WAX MOTHS AND AMERICAN FOUL BROOD.

By E. F. PHILLIPS, PH. D., *In Charge of Apiculture.*

III. BEE DISEASES IN MASSACHUSETTS.

By BURTON N. GATES, *Expert in Apiculture.*

IV. THE RELATION OF THE ETIOLOGY (CAUSE) OF BEE DISEASES TO THE TREATMENT.

By G. F. WHITE, PH. D., *Expert in Bacteriology.*

V. A BRIEF SURVEY OF HAWAIIAN BEE KEEPING.

By E. F. PHILLIPS, PH. D., *In Charge of Apiculture.*

VI. THE STATUS OF APICULTURE IN THE UNITED STATES.

By E. F. PHILLIPS, PH. D., *In Charge of Apiculture.*

VII. BEE KEEPING IN MASSACHUSETTS.

By BURTON N. GATES, *Expert in Apiculture.*

Smithson
APR 4
No 23475

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 75.
L. O. HOWARD, Entomologist and Chief of Bureau.

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1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

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Mabel Colcord, *librarian.*

Bee Culture Investigations.

E. F. Phillips, *in charge.*

G. F. White, *expert in bacteriology.*
B. N. Gates,[a] A. H. McCray, *apicultural assistants.*
J. A. Nelson, R. E. Snodgrass,[a] *agents and experts.*
Ellen M. Dashiell, *entomological preparator.*
T. B. Symons, College Park, Md., *collaborator for Maryland.*
H. A. Surface, Harrisburg, Pa., *collaborator for Pennsylvania.*

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[a] Resigned.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., December 3, 1910.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 75, seven papers dealing with bee culture. These papers, which were issued separately during the years 1907, 1908, and 1909, are as follows: Production and Care of Extracted Honey, by E. F. Phillips, and Methods of Honey Testing for Bee Keepers, by C. A. Browne; Wax Moths and American Foul Brood, by E. F. Phillips; Bee Diseases in Massachusetts, by Burton N. Gates; The Relation of the Etiology (Cause) of Bee Diseases to the Treatment, by G. F. White; A Brief Survey of Hawaiian Bee Keeping, by E. F. Phillips; The Status of Apiculture in the United States, by E. F. Phillips; Bee Keeping in Massachusetts, by Burton N. Gates.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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[a] The eight papers constituting this bulletin were issued, two on December 19, and one each on December 31, 1907, June 30 and December 26, 1908; January 19, January 25, and May 24, 1909, respectively.

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U. S. D. A., B. E. Bul. 75, Part I.   A., December 19, 1907.

MISCELLANEOUS PAPERS ON APICULTURE.

PRODUCTION AND CARE OF EXTRACTED HONEY

By E. F. Phillips, Ph. D.,
In Charge of Apiculture.

INTRODUCTION.

Since the invention of the centrifugal honey extractor, in 1865, and its introduction into America, a constantly increasing proportion of the honey of the United States has been put on the market as extracted. Formerly honey was rendered free from comb by mashing full combs of honey and straining the liquid through a cloth. This is "strained honey," but the same name still clings, in some quarters, to the article removed from the comb by centrifugal force. The production of extracted honey requires much less labor on the part of the bee keeper than does the production of comb honey, and it has several advantages over the latter. The principal reason why extracted honey is more generally produced in the United States than formerly may probably be found in the increasing demand for honey for baking and confectionery purposes; considerably more than half of the honey put on the markets is used in this way.

The ease with which extracted honey may be adulterated has, however, made the general public sceptical as to its use for table purposes; glucose, cane sugar, invert sugar, and other adulterants have been very extensively used, and are still used to some extent. However, the passage of the food and drugs act of June 30, 1906, and the recent work of this Department in the inspection of the honey market have resulted in much good, and persons who have openly adulterated extracted honey in the past are now generally obeying the law. While there is still some cause for complaint, the percentage of adulteration must gradually decrease. The effect of pure-food agitation can not but result in great good to the honest honey producer and bottler.

The chemical detection of honey adulteration has been made more certain by the recent investigations of Dr. C. A. Browne, of the Bureau of Chemistry, and because of the improved methods advocated by him the detection of infringements of pure-food laws will be easier in the future. For a discussion of this work the reader is referred to Bulletin No. 110 of the Bureau of Chemistry, entitled "Chemical Analysis and Composition of American Honeys."

Some of the common practices of bee keepers are, however, open to serious question, and it is primarily to call attention to these that the present paper is presented. It is possible to treat pure high-grade extracted honey so that on chemical examination it would be condemned or called in question. In the past there has been some trouble in cases where chemists have declared honeys, to which nothing has been added, to be adulterated; part of the fault possibly lies with the use of poor methods by chemists, but not all of it. If a bee keeper treats pure honey so that its chemical composition is changed, it is no longer honey, and should not be sold for such. Several of the most widely circulated text-books on apiculture advocate very questionable practices.

There are several text-books giving detailed information as to the production and care of extracted honey. It is not the purpose of this paper to replace these, but to point out the main principles to be observed, and especially to call attention to a few points which do not seem to be understood by the majority of honey producers. Many details which are apparently unnecessary in most cases are omitted, since the writer believes that each bee keeper must find out many minor details in his own experience, and less important phases of the work may better be learned from other sources.

THE ADVANTAGES OF THE PRODUCTION OF EXTRACTED HONEY.

It is not the purpose of this paper to advocate the production of extracted honey as preferable to that of comb honey, nor would it be at all desirable to have the production of fancy comb honey diminished. For the benefit of the honey market, however, it could not result in anything but good were the poorer grades of comb honey to be sold as extracted. The discolored ("travel-stained") and irregularly or partially capped comb honey found on so many markets is a poor advertisement for the the bee keeper who tries to produce a fancy article.

The production of extracted honey means considerably less labor for the bee keeper and also less work of certain kinds for the bees, for it is not necessary for the latter to secrete so much wax. Since it takes several pounds of honey under most conditions to produce 1 pound of wax, the surplus per colony is greater with extracted honey than with comb, but this is compensated by the fact that comb honey of equal grade universally sells at a higher price.

In the production of extracted honey it is much easier to control swarming, since the brood chamber is not contracted so much and the queen has an opportunity to work to her maximum capacity. On the other hand, the colony is usually stronger, with more field bees; this is probably a large factor in the increased amount of surplus obtained from a colony run for extracted honey.

When the honey flow begins, the bees can at once commence to store honey in extracting combs, provided the bee keeper is careful to put them on in time, but in comb honey production it is first necessary for the bees to secrete a considerable quantity of wax before there is room for honey in the surplus boxes or sections and honey is consequently stored in the brood chamber; if much honey is stored here, the queen is cramped for room to lay. The novice at extracted honey production should be careful not to extract so much of the honey in the hive that the bees will not have enough to live on. This is a very common error until the bee keeper is taught by experience how much to extract. It is better to extract too little than too much.

METHOD OF PRODUCING EXTRACTED HONEY.

THE HIVE.

The hive used for extracted honey production should be at least as large as 10 frames. However strongly the advocates of 8-frame hives or even smaller ones may urge the advantage of a contracted brood chamber in order to crowd the surplus honey into the upper stories, certainly these small hives have little place in the production of extracted honey. The queen should have at least 10 frames for brood rearing, if the bee keeper is to expect the maximum results. The use of large hives is upheld by the practices of the largest and best extracted-honey producers of the United States, and the small hives have small sale among extensive producers.

BROOD MANIPULATION.

In the production of honey, either comb or extracted, it must be remembered that if the honey flow is short, only those bees which are fully developed at the beginning of the flow are of any value in honey gathering. The amount of brood reared normally increases at the beginning of a honey flow, especially with Italian bees, but this brood is rarely of much use in producing honey gatherers. In many cases it may be desirable to retard brood rearing at the beginning of the flow by caging the queen or even by removing frames of brood. On the other hand, it is advisable to see to it that brood rearing is extensive for several weeks before a honey flow is expected. This may be brought about by stimulative feeding and by the cautious spreading of brood in the colony. This procedure usually pays well. A careful study of locality conditions is necessary before planning operations of this nature.

TIERING.

Before, or just at the time of the beginning of the honey flow, a hive body exactly similar to the brood chamber should be given to the colony. Many bee keepers put only 8 or 9 frames in a 10-frame hive body used as a surplus chamber so that the bees will build thick combs. Since in uncapping the honey the comb is cut down to about normal thickness, this gives a place for the immediate storing of surplus honey and at the same time permits the bees to secrete some wax. The physiology of wax secretion is very imperfectly understood, but probably wax is always secreted, to a greater or less extent, during a heavy honey flow, and by spacing wide this wax is saved to the bee keeper.

As the frames of the second hive body become filled, the honey may either be extracted at once and the frames returned to be refilled or an additional hive body full of frames may be put directly over the brood chamber and below the first surplus body. Bees go unwillingly through combs of sealed honey to empty combs higher up, but the new combs should be between the first two hive bodies. The reasons for tiering up hives rather than immediate extraction will be discussed under the heading of "Ripening honey." This operation may be continued as long as room is required, and the bees should never be unduly cramped for room. On the other hand, it is usually not desirable to give too much room at one time for surplus, for the honey may be spread over all the combs and, as a result, the cells capped when not drawn out well. It is sometimes desirable in the early part of the season to give only two or three frames for surplus at first, gradually increasing the number as necessity arises. This is particularly the case in uncertain weather or in a light honey flow.

When the surplus combs are first put on, one or two frames containing brood with the adhering bees are frequently placed in the second story and empty frames put in their place in the brood chamber. By this means the bees at once get into the second story, and this manipulation is a very desirable thing where brood frames are used for extracting. When only clean combs are used, these brood frames may be returned to the brood chamber in a day or two, for by that time they are usually no longer needed. Of course care must be taken not to lift the queen to the second story above the perforated zinc.

Some bee keepers prefer the use of shallow extracting combs of a depth about half that of the ordinary brood frame. The advantage of such a size of frame is, briefly, the possibility of putting on a smaller amount of storing room at one time, in consequence of which the honey is capped over in a better manner. In other words, the forcing methods of comb honey production are carried over into the production of extracted honey. It would certainly be unwise to recommend or condemn this system in general, for its use should be governed by local conditions of the honey flow. In this case, as in many others, the maximum results may not be expected without a careful study of local conditions. Bee keepers talk a great deal about "locality differences," and, as generally used, the term "locality" is only an excuse for a lack of information as to the true cause of various observed facts. It is nevertheless most true that there are scores of local differences which are great enough to bring success or failure, according as they are studied or neglected.

PERFORATED ZINC.

The use of a perforated zinc queen-excluding board between the brood chamber and the surplus bodies is gaining in popularity. Without this zinc the queen is likely to go into the second story, or even higher, particularly toward the close of the season. Some bee keepers prefer to use combs for extracting which have never been used for brood, and if this plan is followed the perforated zinc is absolutely necessary. Honey extracted from dark combs which have been used for brood is darker in color as a rule than that produced in combs which have never contained brood. This is doubtless due to the fact that a certain amount of the larval skins and larval excreta which are packed at the bottom of brood cells becomes dissolved in the honey. These deposits in the cells are usually spoken of as "cocoons," but certainly only a small part is really the silk of the cocoon. If this really were merely a cocoon, no possible objection could be made to the use of brood combs for extracting. It would probably do little good to advocate the universal use of only such combs as had not been used for brood rearing in the production of extracted honey, but a strict regard for cleanliness would most assuredly demand it.

REMOVING HONEY FROM THE HIVE.

Honey should not be taken from the hive until fully "ripened." When the time comes to extract, the frames should be lifted from the hive and the adhering bees shaken or brushed off. They may be brushed off with a regular bee brush, many styles of which are manufactured, or a bunch of grass or weeds will usually answer as well. The only advantage of a regular brush is that it is always ready for use.

If the honey flow is over or the bees are hard to manipulate on account of their stinging, a bee escape is desirable. The escape is so arranged that the bees can pass down to the story below with comparative ease but can not get back. Within a few hours the upper story is cleared of bees and the frames of honey may be removed easily. If the queen is in the upper story, however, as she may be if no perforated zinc is used, or as she occasionally is anyhow, the bees will not desert the brood, and there will still be bees on the combs. Escapes may be put on by quickly lifting the upper story and inserting the board in the evening, and by the next morning the upper story will usually be entirely clear of bees.

After the combs are removed from the hive, they should be kept covered so that the bees in the air will not begin to rob. The manner of carrying them to the extracting room will depend on the number of combs to be carried and the arrangement of the apiary. Tin buckets holding five combs at a time may be used; an extra hive body is often fixed with a handle and cloth cover, or the entire hive body may be carried in on a cart or otherwise if it is free from bees.

THE EXTRACTING ROOM.

The place where the honey is extracted should be so arranged that no bees can enter it when attracted by the odor of the honey. The windows should be so built that if some bees do enter they can easily get out through bee escapes or cones so constructed that no other bees will be able to find the opening. Bee escapes may be used, but usually a better plan is to have the windows covered with wire cloth tacked on the outside, the wire cloth extending above the window about 6 inches and held away from the side of the house by quarter-inch strips. Bees almost always crawl upward and they will crawl up the netting and out through the top openings, but other bees will not try to get in that way. A screen so arranged will allow a very large number of bees to escape very quickly. That the extracting room be "bee tight" is practically the only absolute requirement. Honey should never be extracted in the open air except during a heavy honey flow, when bees are not inclined to rob. Where several apiaries are under the management of one man, it is sometimes desirable to make a portable extracting house on wheels so that it may be taken from place to place.

UNCAPPING HONEY.

The honey, before it is extracted, must be uncapped, and this should be done with a long knife which is kept *sharp*, *clean*, and *warm*. There are several types of uncapping knives. If a considerable amount of honey is to be extracted, it is desirable to have two or more knives for each operator so that one may be heated in hot water as the other is used.

As the cappings of wax are cut off some honey flows out, and consequently the uncapping should be done over a regular uncapping box or can. This may be easily made at home to suit individual requirements, or any one of the several types offered for sale may be used. The boxes are either made of metal or lined with tin to prevent the leakage of honey, and about halfway up is a heavy wire netting to catch the wax cappings and allow the honey to drain off into the lower compartment. This honey may later be added to what comes from the extractor.

THE EXTRACTOR.

The extractor consists of two or more baskets into which the combs of honey are placed and which are revolved inside or with a can. The rotation drives out the honey by centrifugal force, leaving the cells empty, provided the uncapping has been thoroughly done. While the extractor is a very simple machine in principle, its construction has been the subject of much experimenting, and various types have been made. The best type of extractor has been found to be one in which the surrounding can is stationary and the baskets are arranged to revolve inside it. Some types are now made so that the baskets may be turned and both sides of a comb emptied without removing the frame from the basket of the extractor. The more elaborate types, holding several frames and driven by power, may be found described in catalogues of the dealers in bee keepers' supplies.

The extracted honey flies to the side of the can and then runs to the bottom of the machine; it then runs off through an opening at the bottom into a vessel or tank for the purpose. As it leaves the extractor it should be run through a cheese cloth to remove any particles of wax or other foreign substance which may have got into it. The care of the honey will be described later.

Empty combs wet with honey should not be returned to the bees while extracting is in progress, for fear of inciting robbing. They may be piled up in the extracting room until the work is almost completed and, if any additional honey flow is expected, they may then be returned. If to be kept until the next year, they should be given to the bees for a short time to be cleaned of honey, and then removed and put away so that wax moths will not destroy them. The greatest essential in the production of the maximum amount of extracted honey is an adequate number of surplus combs.

THE RIPENING OF HONEY.

When nectar is gathered from flowers by the worker bees, the amount of water contained in it is very high. It is generally supposed that, by the time bees reach the hive to deposit the nectar in the cells, part of this water has been removed; at any rate, during the process of ripening, the amount of water is very much reduced, until, in thoroughly ripened honey, it will not exceed 25 per cent and is generally not more than 20 per cent. Some very ripe honeys will have as little as 12 per cent of water in them. If more than 25 per cent of water remains in the honey at the time of extraction, it will probably ferment. The ripening of honey consists not only of the evaporation of the surplus water of the nectar, but especially of the transformation of the sugars of the nectar into the levulose and dextrose of honey. Unripe honeys contain a larger proportion of sucrose or cane sugar, and it is probable that the longer the honey remains in the hive the less of sucrose will be found in the honey. While honeys vary all the way from zero to 8 or 10 per cent in their sucrose content, the purest honeys are those which contain the least. The official honey standard of the Association of Official Agricultural Chemists allows 8 per cent of sucrose in honey.

It is the policy of most bee keepers to allow this ripening to take place in the hive by waiting until the honey is almost all or entirely capped, and this is undoubtedly the preferable method. It is a matter of common observation that honey which remains in the hive for a long time has a better " body " and has more of the characteristic honey aroma. By ripening in the hive honey gets its characteristic flavor to a greater extent than is possible in evaporation outside the hive.

Several machines have been devised for the artificial ripening of honey which has been extracted " green," that is, with too great a water content. The principle on which all of these are constructed is the application of heat, not to exceed 160° F., for a sufficient time to reduce the amount of water present to about 20 per cent. Either sun heat or artificial heat may be used. In the western part of the United States honey may be, and usually is, extracted before it is all capped, because it is the general practice of bee keepers to run the honey directly from the extractor to large tanks, sometimes holding several tons, out in the open, covered with porous cloth tightly tied down to exclude bees. Many of these tanks are contracted at the top, leaving only a comparatively small opening. On account of the extreme dryness of the atmosphere and total lack of rain during the dry season, this partial evaporation outside of the hive takes place very rapidly.

The advocates of ripening outside of the hive argue that, if honey is extracted before all the water is removed from it, the bees have less to do inside the hive and can devote almost all their time to gathering nectar in the field. This obviously would result in an increased amount of nectar and, consequently, provided the forage will produce it, in an increased amount of honey. They argue that it is impossible to detect any difference between honey ripened inside the hive and that ripened outside, as far as flavor is concerned, but this is a point on which many other bee keepers and experts in honey tasting do not agree with them. It must be admitted that, for general sale, the delicate aromas of well-ripened honey are not necessary, since the purchasing public is, as a rule, not educated on this point; but it certainly pays to produce the very best article possible for the further education of the trade, and, therefore, a thorough ripening inside the hive is very much preferable. To insure this, it is better to tier up the hives rather than extract as soon as a hive body is full.

On all honeys, after extracting, if allowed to stand in a vessel, a scum will rise to the top, made up of impurities, such as wax, brood, dead bees, and particles of dirt which may get into it. This is particularly the case with honeys which are extracted when not thoroughly ripened. In all cases honey should be strained as it leaves the extractor and subsequently skimmed until no further impurities come to the top. It is frequently the practice to draw honey from the bottom of the tank in which the honey is stored through a " honey gate," so that the impurities do not get into the smaller receptacles in which the honey is to be packed.

The thorough ripening of honey can not be too strongly recommended. Honey attracts moisture, and there is always a tendency for a very thin layer to form on the top in which the water content is very high. In such a film the amount of sugar is low, the acetic-acid-forming bacteria can grow rapidly, and the honey becomes sour. In thoroughly ripened honey it is very probable that a film of thinner honey is always present, but in such a case the sugar content is so high that the bacteria can not grow.

It is desirable that honeys from different sources be kept separate as far as possible if the product is to be used for the bottling trade. This can be done only by extracting at the close of each honey flow. While it is probably impossible to get a honey from only one species of plant, except under the most unusual circumstances, at the same time honey may generally be removed at the close of each flow, so that the total quantity will have the characteristic flavor imparted by a single kind of flower.

THE GRANULATION OF HONEY.

Almost all honeys granulate or " candy " after a certain time, and may become solid. This phenomenon varies greatly with different honeys. For example, alfalfa honey produced in Colorado will often granulate solid within a few weeks from the time it is extracted, while the white-sage honey of southern California will often remain liquid and entirely clear of crystal for two years and sometimes longer, if properly put up. The reason for this difference in the time of granulation will be discussed under the heading of " Types of Honey." Honey from the same species of plant varies somewhat in this respect in different localities.

Formerly the general public was suspicious of granulated honey, in the belief that it contained cane sugar, but, fortunately, it is now generally understood that pure honeys will granulate in time, and this crystallization is generally considered as a test of purity. The education of the purchasing public has so far progressed that now some bee keepers prefer to sell their honey in a solid granulated condition, it being cut up into bricks and wrapped in oil paper.

In bottling honey, or in putting honey from any large receptacle into smaller ones, it is necessary to liquefy the entire quantity completely before the operation is begun. This may be done by immersing the receptacle in water which has been heated to 160 or 170° F., and letting it remain until the honey is all liquid and free from crystals. Honey should never be liquefied by direct application of heat, and it is extremely important that it should not reach a temperature of more than 160° F. It is well known to almost all bee keepers that honey heated to higher temperatures will become darker in color and lose flavor, and, consequently, they are generally very careful on this point. There is, however, a very much more important reason for avoiding high temepratures. When honey is heated to 180° F. and more, the higher alcohols which give honey its aroma are driven off and, more than that, a decomposition of certain of the sugars takes place; this is what gives the darker color to the honey. Of all the various substances used for the adulteration of honey the one most nearly resembling pure honey is invert sugar, of which Herzfelt's artificial honey is one of the best illustrations. In the detection of adulteration, one of the tests for the addition of invert sugar is based on the presence of decomposition products due to heat. These decomposition products in invert sugar are probably identical with the decomposition products in overheated honey; at any rate, honey which has been heated to more than 180° F. for any considerable time gives the test for invert sugar and would, therefore, be declared to be adulterated if this test were applied by a chemist. A bee keeper might argue that he was not infringing on the pure-food law in overheating his honey, since he had added nothing in the way of an adulterant. If, however, he changes the chemical composition of his honey by injudicious treatment it is no longer pure honey, and he has no right to sell it under that name.

It is very much safer to liquefy honey at a temperature of about 140° F. and thus avoid any danger of decomposition. If this lower temperature is used it is of course necessary to keep the honey at this temperature for a considerable time, but the safety of such a proceeding makes the extra time well worth while.

Two or three of the most widely circulated American text-books on bee keeping advocate the drawing off of the liquid portion of granulated honey, particularly in the case of honey which was not thoroughly ripened before it was extracted. The granulated portion is then allowed to liquefy and is recommended as a very fine quality of honey. This practice is in no way permissible, as will be readily seen if the composition of honey is studied. Honey is made up of dextrose and levulose in about equal quantities, sucrose, a certain amount of ash, and water. In granulation, the dextrose crystallizes readily and the levulose probably does not granulate at all. If, then, the liquid portion, consisting largely of levulose, sucrose, and water, is removed by draining or by pressure, the remaining portion is not honey, but dextrose. However fine the flavor of such a compound may be, it is not honey and can not truthfully be sold as such.

Since honey separates into its component parts in granulation, it is very necessary that all the honey in the receptacle be liquefied and thoroughly mixed before any portion is removed from it for bottling or canning. If, for example, honey is in a 60-pound can and is to be transferred to 1-pound bottles, it is necessary that the entire 60 pounds be liquefied and mixed before any is poured out into bottles, in order that all the bottles may contain honey according to the legal standard. Unless this is done, some of the bottles will contain a high percentage of dextrose and will granulate rapidly, while others will contain a preponderance of levulose and will not granulate for a long time. Unless this mixing is done thoroughly, none of the bottles will contain absolutely pure honey. In order to protect himself, the bee keeper must be very careful on this point. Some bee keepers prefer to pour the honey cold into the bottles and heat it afterwards before sealing. As a matter of convenience this has many points in its favor, but in view of the separation into component parts which may take place it is a bad practice. The honey should first be heated and liquefied completely, especially if honeys from several species of flowers are to be blended.

As previously stated, there has existed and possibly still exists a popular idea that granulation indicates adulteration by the addition of cane sugar. This is of course untrue, since pure honeys do granulate solid. Many bee keepers in combating this idea have stated that this very granulation is a test of the purity of the honey. This statement, so frequently made, is equally untrue, since invert sugar, one of the adulterants sometimes used, will also crystallize solid as rapidly as do most honeys.

Age seems to affect honey greatly. Repeated granulation and liquefaction, as the temperature varies year after year, in some way affects the chemical composition of the honey, changing the product so that it may not have the composition that it had at first. Some honey thirty-five years old, submitted to this Department, was found to contain too much sucrose. A sample of the same honey had previously been analyzed by two official chemists and declared to be adulterated; but the history of the sample precluded this possibility. The honey had apparently changed greatly with age in appearance as well as in composition.

Some bee keepers make a practice of adding a very small amount of glycerin to the honey to prevent granulation. This should not be done, for it is adulterating the honey. Some have argued that, since glycerin costs so much more than honey, they are not adulterating in that they are not adding something cheaper to the honey to increase their profit. According to pure-food laws, however, nothing can be added to honey unless the addition is specifically stated, and the addition of even a small amount of glycerin is, in the eyes of the law, as great an offense as the addition of glucose.

HEATING HONEY FOR THE DESTRUCTION OF THE BACTERIA OF DISEASE.

The only condition under which honey should be heated to a higher temperature than 160° F. is in the case of honey which has been extracted from a colony containing foul brood. In order to kill the bacteria of either of the brood diseases, it is desirable to dilute the honey by adding an equal amount of water and then raise the temperature to the boiling point and keep it there, allowing the mixture to boil vigorously for at least thirty minutes; in order that no risk may be run, it is better to make this one hour. Honey which is so treated is changed chemically and is no longer pure honey, but it makes a good sirup for feeding to bees and is the best way of using honey from an infected source. Too much care can not be exercised in bringing this to the proper temperature, and it must be remembered that the resulting product is not honey, but a sirup, the chemical composition of which is quite unlike that of pure honey.

PACKING OF EXTRACTED HONEY.

If honey tends to granulate rapidly, it will save much trouble in liquefying to put it into the receptacle in which it is to be sold as soon after extraction as possible. There will then be no difficulty from the various ingredients becoming separated. To preserve the delicate aromas it is desirable that honey be sealed as soon as possible.

When honey is put up in less than 3-pound packages it is generally bottled. A bottle makes a much more attractive package than a tin can and shows off the contents. There is no doubt of the fact that honey sells largely on its appearance, and too much care can not be exercised in packing and labelling so as to make the package attractive to the purchaser. In cases where a bee keeper sells directly to a local trade he may educate his customers to judge his honeys by their flavor, in which event it is immaterial what kind of package is used, and honey may even be run out from a large can into a vessel furnished by the customer when the honey is delivered. It is too often the case, however, that bee keepers put up their honey in such poor, unsightly packages that they can get only a low price for their goods.

If honey is put up in more than 3-pound packages, tin cans are generally used and the most common receptacle is a square can holding 5 gallons (60 pounds). Two of these are usually boxed together for shipment. Square and round cans of various types are often used for smaller quantities. Barrels are preferred by some for large shipments for the baking and confectionery trade, but their use can not always be advised. Before honey is put into it, a barrel must be thoroughly dry, and tight when dry, because of the fact that honey takes up a certain amount of moisture, and if, when the honey is put into it, the barrel is damp, the honey will absorb the moisture, causing the barrel to leak. Barrels also absorb a certain amount of honey. In dry climates particularly barrels should be used with caution.

When honey is packed in bottles, it is desirable that granulation be retarded, since a bottle of partially granulated honey is not attractive. To aid in the retarding of granulation, the honey should be entirely liquefied and thoroughly mixed in a large can and run into the bottle warm. The bottle should be as full as possible and sealed hermetically while still warm. Granulation usually begins on the edges of the top line of the honey and spreads rapidly from these points. This is probably because some honey gets upon the sides and partially dries. It is therefore desirable that the honey fill the bottle clear to the cover to prevent this. It must also be free of bubbles. Bottles may be hermetically sealed by using some style of clamp cover or by sealing a cork with a mixture of beeswax and resin. This mixture may be colored by the addition of a dye. Granulation may be considerably retarded by keeping the honey at a nearly uniform temperature. This should not be less than 65° F. and is much better at 90° to 100° F. While the honey is in the hands of the producer or bottler, it may be kept liquid for a long time in this way, but of course when sold it is generally subject to changes of temperature. Honey, either in the comb or extracted, should never be kept in a cool or damp place.

THE PRODUCTION OF "CANDIED" HONEY.

Honeys of the average type, relatively free from nonsugars, such as that made from alfalfa, soon granulate solid and are sometimes sold in bricks. Granulation may be hastened by changes of temperature and by stirring. If it is desired to have a can of honey granulate rapidly, it may be carried from a warm room out doors in winter and back again at intervals of a day or two for a couple of weeks. If this is accompanied with occasional stirring when granulation first begins, the whole can will soon be a solid cake. Honey may also be poured into smaller receptacles, such as waterproof pasteboard carriers or oyster pails, and allowed to crystallize in the package in which it is to be sold. If allowed to granulate solid in a large tin can, the tin may be cut away and the honey cut into bricks with fine wire in the way that prints of butter are sometimes prepared.

A market for "honey bricks" must generally be built up locally, for as yet the general public has not learned to look for honey in such shape. The cost of the package is less than that of bottles, and the granulated honey is by some considered superior for table use to liquid honey. Several bee keepers have used this method with success and claim that it gives great satisfaction to their customers.

HONEY TYPES.

It is well known that honeys from different plants vary considerably in taste, color, granulation, etc. The taste and color are given to honey by the plants from which the nectar is derived. Granulation may be considered as a property of all honeys, or rather of the dextrose contained in all of them, and, from a study of the chemical composition of many samples, it seems probable that all honeys would crystallize were it not for the fact that some of them contain an excess of either noncrystallizable levulose or dextrin, gums, and other nonsugars. The following table will make this point clear:

I. Normal honey (from nectaries of flowers).
    1. High purity (high in sugars, relatively low in dextrin, gums, and other nonsugars).
        A. Levulose type, e. g., mangrove, tupelo, sage.
        B. Average type.
            a. High in sucrose, e. g., alfalfa.
            b. Low in sucrose, e. g., buckwheat.
    2. Low purity (relatively high in dextrin, gums, and other nonsugars, e. g., basswood, sumac, poplar, oak, hickory, apple, most tree honey).
II. Abnormal honey (not from nectaries of flowers; generally high in dextrin, gums, and other nonsugars).
    1. Honeydew honey (from aphides and other insects).
    2. Coniferous honey (plant exudations not from nectaries).

Honeys containing approximately the same amount of levulose and dextrose and which are high in sugars (average type) granulate readily. Very few honeys have more dextrose than levulose. If, however, the levulose is considerably greater than the dextrose (levulose type), or if the nonsugars are relatively high (low purity and abnormal honeys), granulation is retarded. Some honeydew granulates rapidly, but no abnormal honeys of that type were included in the samples examined, consequently they are not included in the table.

The use of the terms " high " and " low " purity in this table must not be taken to indicate the comparative values of the various honeys. Low-purity honeys which have relatively more dextrin, gums, and other nonsugars are just as good honeys as those of the high-purity class. Abnormal honeys, however, are less desirable. The presence of the nonsugars in low-purity honeys may be due largely to a slight admixture of honeydew, since most honeys contain a trace of this. It must be remembered in considering this subject that practically no honey is from a single species of plant, and therefore they will vary considerably, according to the other nectars added to them as well as according to local soil and climatic conditions.

METHODS OF HONEY TESTING FOR BEE KEEPERS.[a]

By C. A. Browne, Ph. D.,
Chief, Sugar Laboratory, Bureau of Chemistry.

The most common forms of adulteration which are practiced at present in the sophistication of honey are the addition of commercial glucose, cane sugar, and invert sugar. The adulteration of honey by dilution with water is less commonly practiced; such addition is easily recognized by the increased fluidity of the honey, and there is, besides, the increased danger that the product will spoil through fermentation. It is often desirable, however, for the bee keeper to know the approximate percentage of moisture in his products in order to avoid the marketing of unripe honey which might exceed the limit for water allowed by the standards (25 per cent). The average water content of American honey, according to the average for 99 pure samples analyzed in the Bureau of Chemistry, is 17.59 per cent, so that there is above this a margin of more than 7 per cent in which the moisture of honeys may be allowed to fluctuate.

The accurate determination of moisture in honey in the chemical laboratory is a somewhat complicated process. A carefully weighed amount of the honey is evaporated at a temperature of about 160° F. in a vacuum chamber until no more moisture is given off, and the loss in weight during the interval is calculated as water. For the bee keeper such a method of determination is too involved and complicated; there is, however, a much simpler method by means of which the moisture content of a honey can be determined with ease and rapidity and with a fair degree of accuracy. This is by means of a specific gravity float or spindle. The liquefied honey is poured into a tall cylinder and immersed in hot water of 170° F. temperature. The honey is stirred with a thermometer and as soon as the temperature has reached 160° F. the spindle is lowered into the honey and allowed to come to rest. The point at which the surface of the honey cuts the graduation mark upon the spindle indicates the percentage of water in the honey.

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[a] This paper was prepared by Doctor Browne of the Bureau of Chemistry after the completion of his work on honey analysis. For greater detail the reader is referred to Bulletin 110 of the Bureau of Chemistry, entitled "Chemical Analysis and Composition of American Honeys." This bulletin may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. It can not be obtained from the Bureau of Entomology.—E. F. P.

For the accurate determination of glucose, cane sugar, and other adulterants, the bee keeper will usually be obliged to resort to the services of a chemist. This is especially true as regards cane sugar, as there is no simple test for this substance which can be applied by the ordinary layman. As regards glucose and added invert sugar, however, there are certain simple colorimetric tests which can be easily and quickly carried out.

A good colorimetric test for the presence of commercial glucose or starch sirup in honey is that of Beckmann, by means of a dilute solution of iodine in potassium iodide. One part of the honey to be examined is dissolved in one part by volume of water in a test tube and shaken up with a few drops of the iodine solution. If the honey solution remains a pale yellow, commercial glucose is probably absent; if the solution is colored a red or purple, however, the presence of glucose sirup is clearly indicated. In making this test it is always best to carry out a comparative test under similar conditions, using a honey of known purity and adding the same number of drops of iodine solution. In this manner a reliable comparison of colors can be secured.

The adulteration of honey with invert sugar sirup is being practiced to some extent in this country, though not as widely at present as in certain European countries. This sirup has in many respects the same composition as pure honey; it is deficient, however, in ash, albuminoids, and other constituents which occur in honey in small amounts. Through the action of the high temperature of boiling a small quantity of decomposition products of sugar is produced in this artificial honey which serves to distinguish it from pure honey unless the latter has been boiled for some time, in which case it also will contain decomposition products similar to those contained in the invert sugar sirup. An easy test for artificial invert sugar in honey is by means of a concentrated solution of aniline acetate. This reagent should be prepared freshly each time before using. Five cubic centimeters of chemically pure aniline are shaken up with 5 cubic centimeters of water and 2 cubic centimeters of glacial acetic acid added. The milky emulsion of aniline and water should clear up perfectly on addition of the acid. About 5 cubic centimeters of the honey to be tested are diluted in a test tube with an equal volume of water and a little of the aniline solution poured down the walls of the tube so as to form a thin layer upon the surface of the liquid. If artificial invert sugar is present, a red ring will form beneath this layer, and on gently agitating the tube the whole quantity of aniline acetate will be tinged this color, the depth of coloration depending upon the quantity of artificial invert sugar present in the mixture. Pure honeys which have not been spoiled by overheating do not give this reaction.

In carrying out the tests previously described only a very small outlay in apparatus will be required. The special spindles for determining the water content of honey and the other apparatus can be obtained from any manufacturer of chemical goods. Glass or metal cylinders for containing the honey while spindling will be needed, as also a collection of test tubes and racks. A small 50 cubic centimeter graduated cylinder will also be found useful for measuring out the volume of honey solutions and of reagents. All apparatus should be thoroughly cleaned and rinsed after using, as any contamination with impurities may affect the accuracy of the tests. The drugs specified may be purchased of any druggist.

U. S. D. A., B. E. Bul. 75, Part II. A., December 31, 1907.

MISCELLANEOUS PAPERS ON APICULTURE.

WAX MOTHS AND AMERICAN FOUL BROOD

By E. F. Phillips, Ph. D.,
In Charge of Apiculture.

INTRODUCTION.

It has generally been held by bee keepers that, while the wax moths often cause considerable damage by destroying surplus combs and in other ways, they were not an unmixed evil, for by destroying combs infected with brood disease they were supposed to remove the infection. Text-books on apiculture and articles in various bee journals have repeatedly reiterated this statement. Evidently no person has seen fit to look into the question thoroughly, and it is the object of the present paper to record some observations which have been made.

When a bee larva dies from infection of American foul brood, it decays rapidly, and the mass becomes ropy, so that if a small stick or pin is inserted in the decayed mass and removed, the larval material adheres to it and will string out for an inch or more. This ropiness of the dead larva is very characteristic of this brood disease. Seemingly this ropiness makes it impossible for the bees to remove the infected material, and when the decayed mass dries down it forms a scale which adheres so tightly to the lower side wall of the cell that it can not be removed without tearing the wax wall.

As the disease progresses in the colony the various cells of the brood chamber come to contain diseased larvæ and, later, scales formed of dried larvæ. It is probable that after a cell once comes to contain a diseased larva, it is almost impossible for another larva to reach maturity in a healthy condition, consequently the number of bees which reach the adult condition is constantly reduced and, as the old field bees die and are not fully replaced, the colony becomes weakened and finally dies out completely.

As long as the colony is strong the wax moths can do no damage, but as the bees decrease in number the combs offer a foothold to one or other of the moths and within a very short time the whole hive is one mass of wax moth tunnels, larval excreta, and cocoons. The combs are completely destroyed and nothing remains but the web and a mass of débris on the hive bottoms. If the moth larvæ actually ate the infected material, they would serve to remove the infection where the bee keeper is too careless to do so—as is too frequently the case.

The two wax moths differ greatly in their habits in some respects, but it is not the purpose of this paper to discuss these points. The large wax moth (*Galleria mellonella* L.) is the most widely distributed and is found in practically every part of the United States, and probably wherever the honey bee is now kept. The lesser wax moth (*Achroia grisella* Fab.), on the other hand, is not so widely distributed, but it is known to exist in various localities in this country.

WORK OF THE LARGE WAX MOTH.

(*Galleria mellonella* L.)

Plate I is from a photograph of a comb, infected with American foul brood, on which larvæ of the large wax moth were placed. The comb was placed in a box to exclude light and was laid flat on a piece of paper. The larvæ at first worked on the under side of the comb, but gradually they got to the upper surface. It will be noticed that in one part of the comb the lower side walls of the cells remain intact; here the dried-down scales of American foul brood were thickest, and evidently this was the center of the brood during the time of infection. The remainder of the area formerly occupied by comb is nothing but débris, with a few scales scattered here and there. Evidently only where scales are thick do they hold together enough to stand upright. To show how the scales stand up, the web was removed from the surface. The background of the photograph is merely a piece of paper.

Plate II is a photograph of a rough box used for a hive during some experiments in producing American foul brood by the feeding of pure cultures of *Bacillus larvæ*.[a] The five frames of this small hive contained thousands of the dried-down scales so characteristic of this disease. The box was put away in a closet and the large wax moth got into it, with the result that all the combs were completely destroyed. The webs and empty frames were removed for this photograph. The black mass in the bottom of the box is composed of

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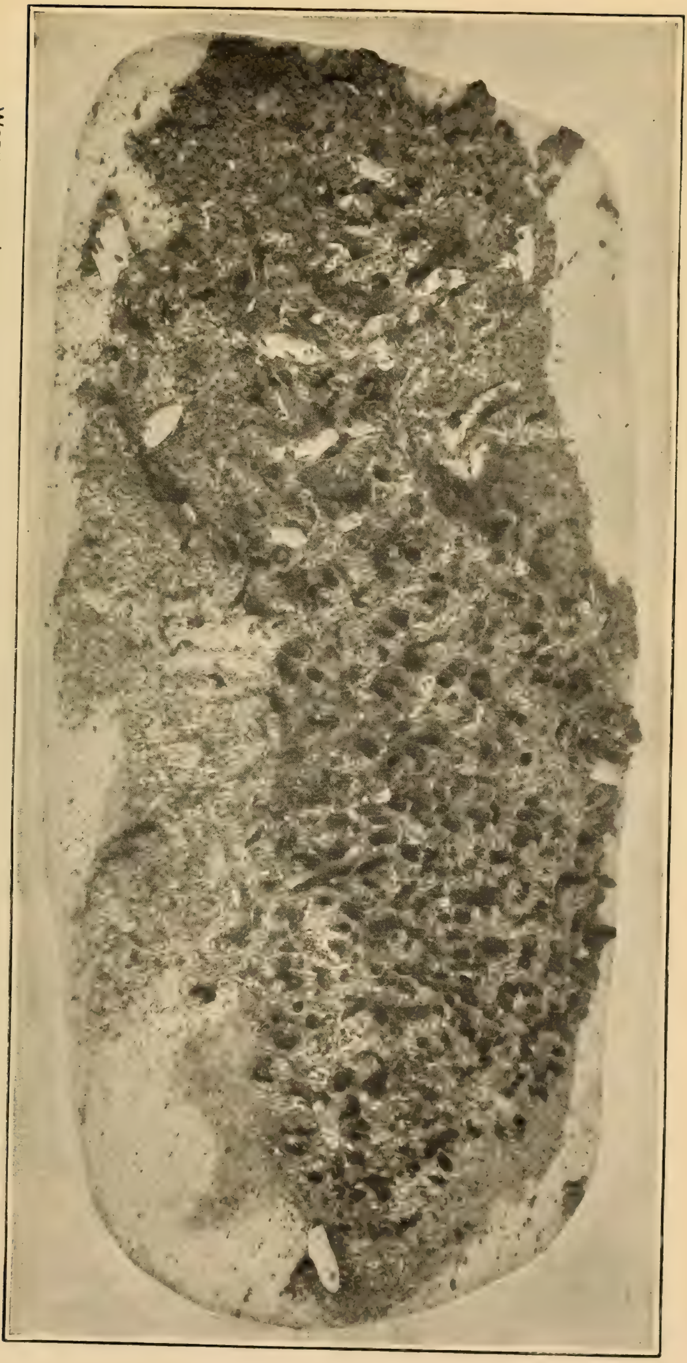
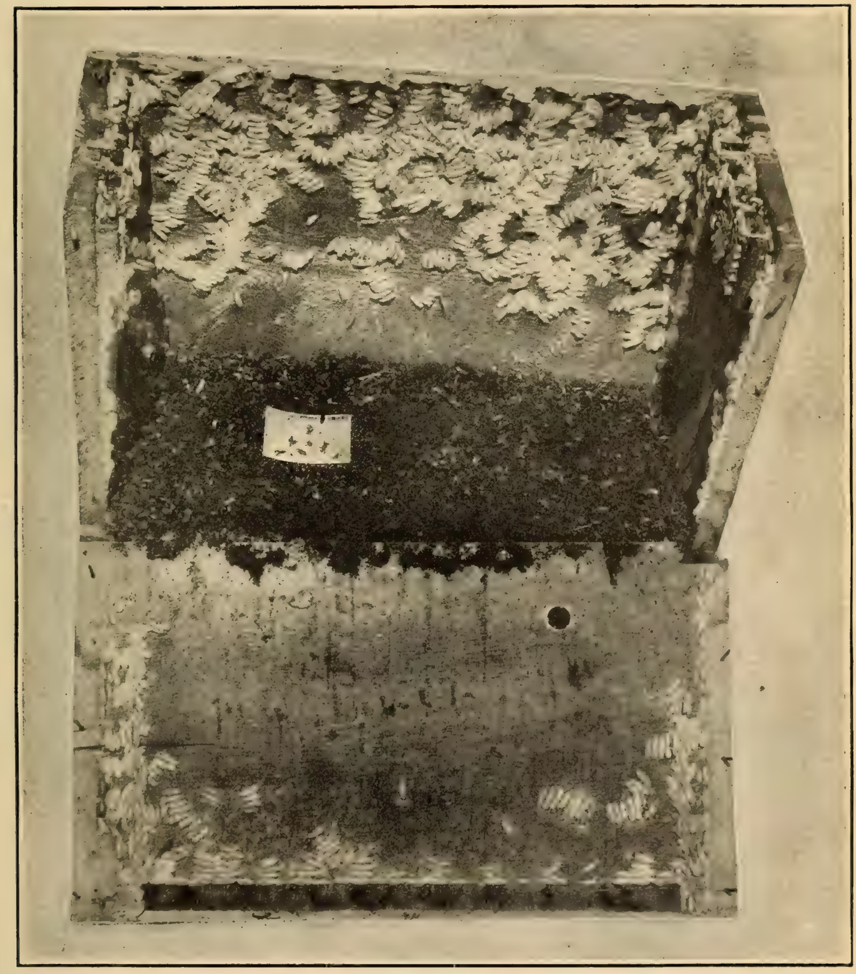
[a] Circular No. 94, Bureau of Entomology, entitled, "The Cause of American Foul Brood," by Dr. G. F. White. Issued July 29, 1907.

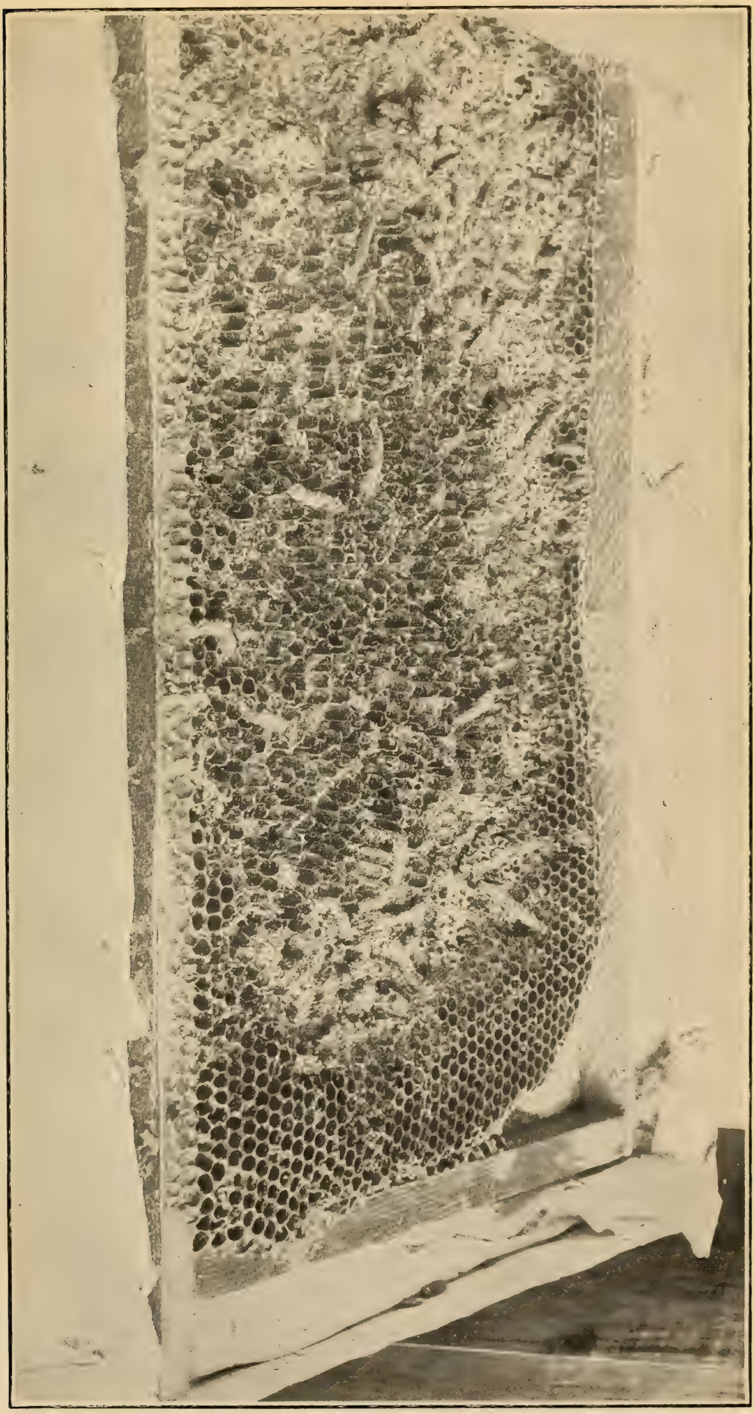


Work of the Large Wax Moth (Galleria mellonella) in Comb Infected with American Foul Brood. (Original.)



HIVE INFECTED WITH AMERICAN FOUL BROOD, THE FRAMES REMOVED TO SHOW WORK OF THE LARGE WAX MOTH (GALLERIA MELLONELLA). (ORIGINAL.)

PLATE III.



Work of the Lesser Wax Moth (Achroia grisella) in Comb Infected with American Foul Brood. (Original.)

larval feces and scales in about equal proportion by volume. On account of the reduction of the photograph the scales do not appear plainly; nevertheless, this demonstrates what becomes of the scales of American foul brood in a set of combs destroyed by *Galleria mellonella.* A few scales are seen placed on a card resting on the mass of feces and scales.

Mr. Burton N. Gates, of this Bureau, took some of these scales and put them in a small box with small larvæ of *Galleria mellonella.* The scales remained untouched and the larvæ died, evidently of starvation.

WORK OF THE LESSER WAX MOTH.

(*Achroia grisella* Fab.)

Plate III is a photograph of a comb taken from a colony which had died of American foul brood. It was obtained by the author in June, 1906, near Fillmore, Ventura County, Cal., and is of interest as coming from an apiary which in less than two years had been reduced from about 200 colonies to 15 by the ravages of this disease. When the apiary was visited there were 151 hives in place, and of these 136 contained no bees. This comb was wrapped up and put away for future study, but became infested with *Achroia grisella.* Whether it contained eggs when taken in the apiary or whether the moths entered after the comb reached Washington is not known.

It is obvious from this illustration that the larvæ have not eaten the scales formed by dried-down larvæ which died of American foul brood. This comb was not cleaned of webs and illustrates very nicely the characteristic work of this moth.

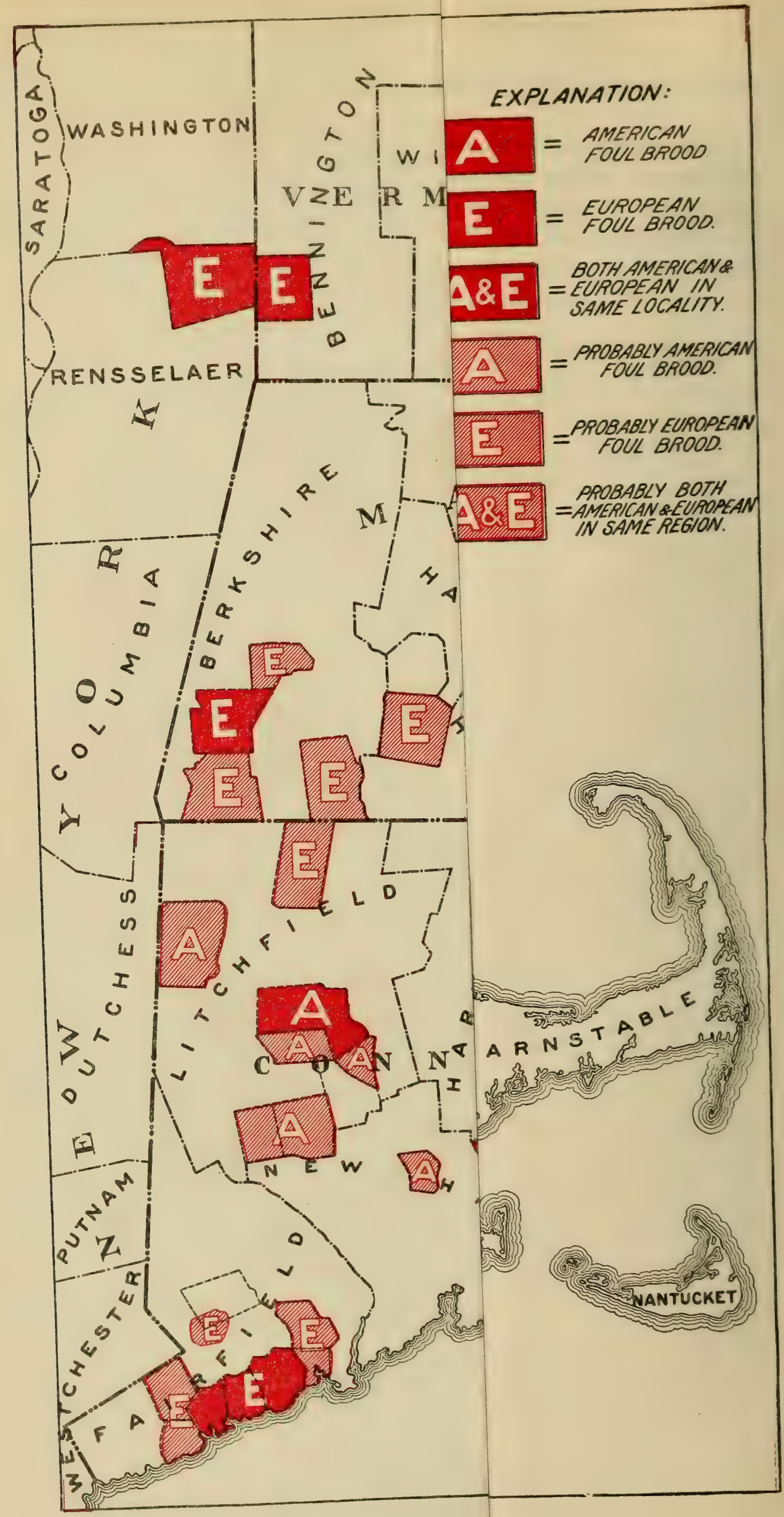
After the photograph was taken the scales were picked out of the frame and this material was used in some of the inoculation experiments recorded in Circular No. 94; obviously, therefore, the material was still infectious.

CONCLUSION.

In the control of brood diseases of bees the constant reinfection of apiaries from diseased combs of colonies in a wild state is one of the things which must be combated constantly. It is not difficult for a bee keeper to rid his own apiary of disease, but he must constantly watch for an introduction of the disease from wild bees or an adjoining apiary. If then the wax moths actually destroyed the infected combs of wild colonies or of colonies in the apiaries of careless bee keepers, they would be a benefit to the industry to that extent. Naturally if the moth larvæ eat out everything except the scales and these drop to the bottom as shown in Plate II, they are less available to other bees. If sufficiently covered with débris, they are to some extent removed from robbing workers.

These results prove conclusively that the two wax moths, *Galleria mellonella* and *Achroia grisella*, do not eat the scales formed from larvæ which have died of American foul brood. It is clear, therefore, that infectious material in a colony dying of this disease remains even after the comb is destroyed. The one point in favor of these moths, from a bee keeper's standpoint, is therefore disproven.

PLATE IV.



MAP SHOWI

U. S. D. A., B. E. Bul. 75, Part III. A., June 30, 1908.

MISCELLANEOUS PAPERS ON APICULTURE.

BEE DISEASES IN MASSACHUSETTS.

By Burton N. Gates,
Expert in Apiculture.

INTRODUCTION.

In Massachusetts bee keeping is not an industry conducted by a few, as in the Hawaiian Islands, where four corporations harvested 600 tons of honey last year; but there are more than 2,100 men who derive some profit from their bees and who have interests at stake. There is besides, a vast, concentrated, and steadily increasing population which, fortunately for bee keepers, provides an almost unlimited home market. In order to point out the status of the industry, the writer estimated in 1904,[a] that two tablespoonfuls of honey per person as a year's ration is all that is now consumed, and of this less than one-fourth is produced in Massachusetts. Theoretically it is possible for Massachusetts to support approximately 40,000 colonies of bees, which could more than equal in amount Hawaii's honey crop for last year. There is reason to believe, however, that bee keeping, if it is not actually decreasing, is not progressing along with the steadily increasing population of the State. This is borne out by the general feeling among the country people that to-day there are fewer bees kept on the farms than there were fifty years ago.

One of the fundamental reasons for this condition may be found in the presence of brood diseases of bees, which exist in practically every quarter of Massachusetts and Connecticut, as well as in the other New England States, and which from time to time have doubtless killed out the bees in many localities. There is undeniable proof of this; furthermore, from evidence of former outbreaks it must be concluded

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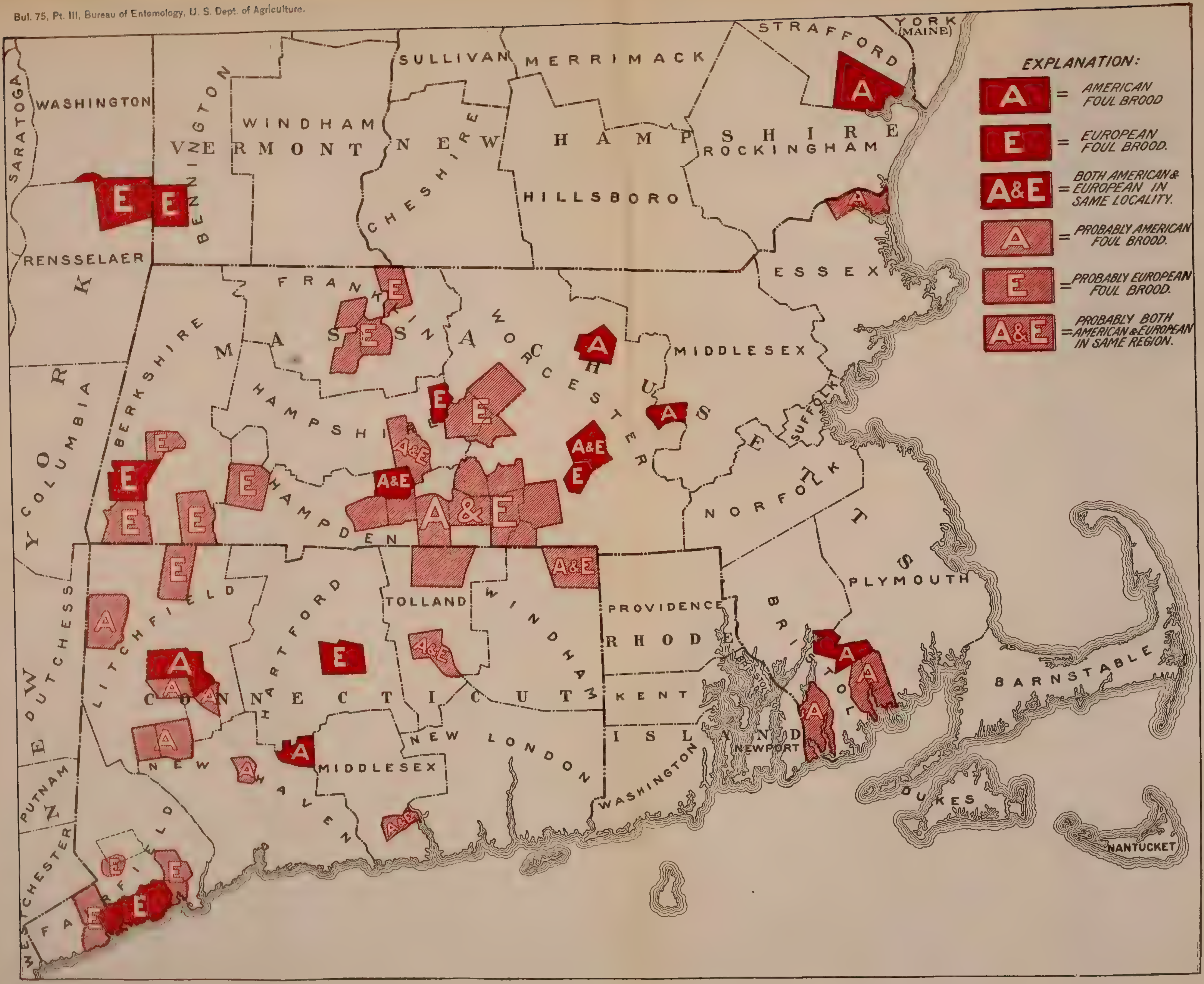
[a] Bee Keeping: How to Meet its Dangers and Difficulties. By Burton N. Gates, with suggestions by Prof. C. F. Hodge. Fifty-second Ann. Rept. Sec. Mass. St. Bd. Agric., pp. 411–426, Boston, 1905. Massachusetts Crop Report, Vol. 17, No. 6, October, 1904, pp. 30–40. Boston, 1904.



Map Showing Distribution of Bee Diseases in Massachusetts and Possible Sources of Infection from Neighboring States.

that their introduction is not recent. This evidence is not merely the result of bee keepers' reports or of more or less semiauthoritative and indefinite rumors, but it is based upon results of bacteriological findings in numerous samples of brood comb sent to this Bureau by the bee keepers in the State during the past year and a half. Under these conditions bee keeping can not be brought to the high degree of perfection which is possible. No factor in bee keeping tends to limit the industry as do epidemics of such diseases; they cause bee keepers to become discouraged by "bad luck" and to lose interest in their bees. The "luck" must change; the bee keepers must learn the nature of the diseases, where they exist, and how to combat them; otherwise the industry will decrease even more.

THE TWO KNOWN BEE DISEASES.

Two contagious brood diseases of bees are now known. These attack the developing brood and so reduce it that the colony soon dwindles from lack of young bees to replace the old. They are known, respectively, as American foul brood and European foul brood.

AMERICAN FOUL BROOD.

The cause of this disease is definitely known to be an organism, *Bacillus larvæ* White. It is what has been heretofore frequently designated simply as "foul brood." The nature of the disease is described by Dr. E. F. Phillips, in charge of apicultural investigations in this Bureau,[a] as follows:

> When the larvæ are first affected they turn to a light chocolate color, and in the advanced stages of decay become darker, resembling roasted coffee in color. Usually the larvæ are attacked at about the time of capping, and most of the cells containing infected larvæ are capped. As decay proceeds these cappings become sunken and perforated, and, as the healthy brood emerges, the comb shows the scattered cells containing larvæ which have died of disease, still capped. The most noticeable characteristic of this infection is the fact that when a small stick is inserted in a larva which has died of the disease, and slowly removed, the broken-down tissues adhere to it and will often stretch out for several inches before breaking. When the larva dries it forms a tightly adhering scale [of characteristic and diagnostic shape and] of very dark brown color, which can best be observed when the comb is held so that a bright light strikes the lower side wall [of the cell]. Decaying larvæ which have died of this disease have a very characteristic odor which resembles a poor quality of glue. This disease seldom attacks drone or queen larvæ.

EUROPEAN FOUL BROOD.

This is the disease which appears to be most prevalent in Massachusetts, probably having swept in from New York State, where it was formerly known as "black brood." Its presence is less easily diagnosed by superficial examination than is American foul brood. It is described by Doctor Phillips[a] as follows:

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[a] The brood diseases of bees. By E. F. Phillips, Ph. D. Circular 79, Bureau of Entomology, U. S. Department of Agriculture, pp. 1–2, 1906.

> This disease attacks larvæ earlier than does American foul brood, and a comparatively small percentage of the diseased brood is ever capped. The diseased larvæ which are capped over have sunken and perforated cappings. The larvæ when first attacked show a small yellow spot on the body near the head and move uneasily in the cell. When death occurs they turn yellow, then brown, and finally almost black. Decaying larvæ which have died of this disease do not usually stretch out in a long thread when a small stick is inserted and slowly removed. Occasionally there is a very slight "ropiness," but this is never very marked. The thoroughly dried larvæ form irregular scales which are not strongly adherent to the lower side wall of the cell. There is very little odor from decaying larvæ which have died from this disease, and when an odor is noticeable it is not the "glue-pot" odor of the American foul brood, but more nearly resembles that of soured dead brood. This disease attacks drone and queen larvæ very soon after the colony is infected. It is as a rule much more infectious than American foul brood and spreads more rapidly. On the other hand, it sometimes happens that the disease will disappear of its own accord, a thing which the author never knew to occur in a genuine case of American foul brood. European foul brood is most destructive during the spring and early summer, often almost disappearing in late summer and autumn.

DAMAGE FROM BEE DISEASES.

The damage from an epidemic of bee disease is as difficult to estimate as is the damage from an epidemic of smallpox, of typhoid fever, or of malaria in a human community. The loss of colonies is but one small item; there is the resulting loss of crop, the resulting lack of increase in the number of colonies of bees, and that demoralizing effect on the industry which tends to cause bee keepers to go out of business. Besides this there is a crippling of commercial queen rearing, a check on the trade in bees, and a decisive effect on the manufacture and sale of bee keepers' supplies. All these factors must be considered in an estimate; and, what is more, the damage is accumulative. It can not be calculated by the year and then totaled; the progressive loss must be figured.

In New York State, where European foul brood has been combated for nearly a decade, and where it is now well suppressed, it has been estimated that the damage from loss of bees alone, in a very limited area, in 1899 and 1900, was at least $45,000.

In Ventura County, Cal., where American foul brood flourishes, a thriftless bee keeper had 151 colonies which, from neglect, were reduced to 14 colonies in a little over twelve months' time. One hundred and thirty-seven colonies had died or were nearly dead. But there are many more and even sadder cases, were there space to relate them.

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[a] The brood diseases of bees. By E. F. Phillips, Ph. D. Circular 79, Bureau of Entomology, U. S. Department of Agriculture, p. 2.

PRESENT EXTENT OF BEE DISEASES IN MASSACHUSETTS.

The extent of bee diseases in Massachusetts may be readily seen on the map. The towns in which they are positively known to occur are listed below in black-faced type. Towns in which they probably exist are listed in lighter-faced type.

Table showing the towns in which the bee diseases respectively occur.

[**Black-faced type** indicates where disease is positively known to exist. Light-faced type indicates that disease is probably present.]

American foul brood.		European foul brood.	
Bristol County: Acushnet. **Freetown.** New Bedford. Westport. *Essex County:* Amesbury. Salisbury. *Hampden County:* Brimfield. **Ludlow.** Monson. Springfield. Wilbraham. *Hampshire County:* Belchertown. *Middlesex County:* **Marlboro.**	*Worcester County:* Brookfield. Charlton. **Leominster.** Sturbridge. Southbridge. Warren. **Worcester.**	*Berkshire County:* **Great Barrington.** Lee. Sandisfield. Sheffield. *Franklin County:* Deerfield. Greenfield. Montague. Northfield. *Hampden County:* Blandford. Brimfield. **Ludlow.** Monson. Springfield. Wilbraham.	*Hampshire County:* Belchertown. **Greenwich.** *Worcester County:* **Auburn.** Barre. Brookfield. Charlton. Hardwick. New Braintree. Southbridge. Sturbridge. Warren. **Worcester.**

The distribution of these diseases is based, as is explained, on bacteriological findings in numerous samples of suspected brood, submitted by the bee keepers during the past year and a half. The examinations were made by Dr. G. Franklin White, expert in bacteriology, of this Bureau. In plotting the regions where disease is thus definitely known to exist a solid red color has been used. Index letters, A for American foul brood and E for European foul brood, show which disease is present in each locality.

Besides these definite data there are in the Bureau of Entomology a great number of reports from bee keepers throughout Massachusetts, which, without the definite knowledge from the bacteriological examinations, would be of slight significance and importance, but which, in conjunction with these findings, are of the greatest value. They indicate regions of probable infection, which are shown on the map in lighter tone.

As an illustration, a bee keeper who lives in Acushnet reports, "I lost all my bees, thirty swarms, at once." This bare statement is of slight import; but taken together with the fact that American foul brood occurs in Freetown, it would indicate that American foul brood is distributed throughout southern Bristol County. Another illustration is found in Worcester County. Bacteriological examination shows that in Auburn and Worcester both European foul brood and American foul brood exist. A bee keeper from Barre reports that in the year 1902 or 1903 he lost forty-five colonies of bees. From East Brookfield and Charlton, from New Braintree, Sturbridge, and Warren, all located around and adjoining Worcester and Auburn, reports of heavy loss of bees, not alone by one bee keeper in a town but by several, are at hand. A bee keeper in Warren says, "Bees all died about five years ago; I had nine colonies which I lost; Mr. —— lost about five colonies also, as did others, so that at the present day only three to four colonies remain in town." Similar reports come from across the county and Connecticut State lines adjoining this section of Worcester County. It is highly probable, then, considering the positive knowledge of foul brood in Worcester and Auburn and considering collectively the widespread and yet individual reports from the country about these two towns, that these diseases are present throughout this section of Massachusetts and Connecticut. In other parts of the State similar conclusions are obvious.

Considering the distribution as a whole, it is apparent that European foul brood has swept in from New York State, where the disease has existed for years. Moreover, were the bees in western Massachusetts systematically examined, this portion of the State would doubtless be found thickly infected with European foul brood. American foul brood in Connecticut has apparently invaded Litchfield County in the western half of the State. In Massachusetts, on the other hand, and in one small area in New Hampshire, where there is less thorough information, American foul brood is largely confined to the eastern half of the State. Ultimately, when more information is at hand, if decisive and immediate steps to suppress these diseases are not taken, Massachusetts, as well as the rest of New England, will undoubtedly reveal a mass of infection.

EVIDENCE THAT BEE DISEASES WERE NOT RECENTLY INTRODUCED INTO MASSACHUSETTS.

In 1828 Dr. James Thatcher wrote (p. 4):[a]

> The destructive ravages of the bee-moth have in many places almost annihilated our bee establishments and discouraged all attempts to renewed trials. No less than a hundred hives have, the past season, been entirely destroyed by that enemy within the towns of the county of Plymouth, and in places where a single hive has yielded one hundred pounds of honey.

At first reading this might appear, so far as bee diseases are concerned, of slight import. General experience shows, however, that strong, healthy colonies of bees are seldom if ever destroyed by wax moths, the presence of the latter being secondary as a result of a weakened condition of the colony from loss of its queen, disease, or the like. Consequently, wherever there is extensive complaint of damage from moths, there the presence of disease is to be suspected.

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[a] A Practical Treatise on the Management of Bees. * * * By James Thacher, M. D., Boston, 1829.

In 1831, again, Dr. Jerome V. C. Smith[a] says (p. 41):

> Great lamentations are heard about the bee-moth, * * * whose devastations in the New England States have been described as something frightful.

More specifically he says (p. 43):

> In the interior of Massachusetts, New Hampshire, and Connecticut the farmers have become heartily discouraged in their attempts at cultivation, and lamentably appear to have abandoned them entirely.

Such reports strongly suggest that some unknown agent, as disease, depleted the bees and made them subjects for the devastations of bee moths. Even at that early date Doctor Smith intimates (p. 41) that all the damage "attributed to it [the bee moth] . . . admits of some doubt." Without being conclusive, such evidence must be accepted as strongly indicative of the existence of disease, probably of American foul brood, in Massachusetts.

About 1896 the writer saw in Worcester a hive in which the bees had died from some affection of the brood. It was diagnosed then as a disease which is now designated as American foul brood. Only one hive out of several was affected.

European foul brood, on the other hand, is of more recent introduction in the State. It was first recognized in New York State in 1895, where it is thought to have been introduced in importations of bees from the south. As the map shows, this disease has probably spread into Massachusetts from New York.

The late Mr. James F. Wood, of North Dana, noticed in the Connecticut and Swift River valleys of Massachusetts a brood disease of bees which made its appearance in that region about 1901. It did much damage, destroying all the bees in the yards where it appeared; but, as it was apparently not American foul brood, Mr. Wood regarded it as a new disease. From a description made in an address before the Worcester County Bee Keepers' Association by Dr. James B. Paige,[b] of Massachusetts Agricultural College, who was closely associated with Mr. Wood and who made a study of the disease, it would appear to have been European foul brood. Being first observed in Massachusetts in 1901, it would have had ample time to have spread from New York State.

With so little recorded data, it is difficult to draw positive conclusions regarding the distribution of these diseases in years gone by. It is far more important, however, to realize that they have existed in the State for a considerable time, that they have been and are a decided check on the progress of bee keeping, but that they can now be counteracted.

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[a] An Essay on the Practicability of Cultivation of the Honey bee * * *. By Jerome V. C. Smith, M. D., Boston, 1831.

[b] Wood's Bee Disease. American Bee Keeper, Vol. 16, pp. 69–70, 1906.

THE SPREAD OF BEE DISEASES.

Both types of foul brood are highly infectious; the way in which they are spread might be compared to the spread of typhoid fever in human communities. Honey is the common carrier of this infection, just as milk and water are the agents which frequently spread typhoid fever.

In diseased colonies of bees, practically every part of the hive becomes contaminated with the germs of the disease. Consequently, when disease is found in the bee yard, every precaution must be taken that bees from healthy colonies do not come in contact with any part of the diseased colonies or hives. Honey, being so irresistible to the bees, is of course the main thing to be guarded. Since diseased colonies soon become weakened, from the lack of young bees to replace those dying from old age, they are less likely to maintain guard against robbers, which are a great source of danger in the spread of infection. Immediately on discovery, diseased colonies should be treated.

FEEDING HONEY.

In these days of widespread bee disease it is dangerous to feed any honey to bees; it is far preferable and less dangerous to supply them, if they need stores, with a sirup of sugar and water, half and half. It is safe to feed honey to bees only when it has been vigorously boiled for at least a half hour, and, as Doctor Phillips has recently stated,[a] in order to avoid risk, "it is better to make this an hour" (p. 12). In boiling, the honey should always be diluted with equal parts of water in order to prevent scorching.

DISINFECTION OF TOOLS AND HANDS.

All tools used in manipulating diseased bees, as well as the operator's hands, should be thoroughly disinfected before opening a healthy colony.

DEPLETED HIVES FROM GREENHOUSES A SOURCE OF DANGER.

In Massachusetts particularly there is another source of infection which is difficult of control. Each year several hundred colonies of bees are placed in greenhouses by those who grow cucumbers under glass. In the adverse conditions of the cucumber house the hive soon becomes depleted and is promptly thrown on the rubbish pile. If the hive originally came from a foul-brood region—which is not improbable, inasmuch as the greenhouse men buy their bees wherever they can get them—all the bees within a radius of several miles of the rubbish pile are exposed. More than once the writer has seen from two to a half dozen such hives cast out on the rubbish heap. While there is no intention of endangering neighbors' bees, it is as criminal to throw out of doors any hive in which bees have died as it is to shake the bedding or throw the waste of the sick room from the window. Discarded hives and their contents, if the cucumber grower does not wish to render the wax, should be thrown under the boiler.

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[a] The production and care of extracted honey. By E. F. Phillips, Ph. D. Bul. 75, Pt. I, Bur. Ent., U. S. Dept. Agric., 1907. Price 5c, from Superintendent of Documents, Washington, D. C.

PURCHASING BEES AND QUEENS.

In purchasing bees the buyer should be as certain that he is getting stock free from disease as is the farmer, who purchases cows, that these have no tuberculosis. A region where the disease is not found or where it has been successfully suppressed can be reinfected by one careless purchase. For instance, speaking of New York State, Mr. Charles Stewart says:[a]

> Just as we [the inspectors] were feeling that we had nearly stamped it [the disease] out and were masters of the situation we discovered that at least one if not two fresh importations had been made in a section of the State where no trouble of this kind [European foul brood] formerly existed (p. 55).

To some degree this applies to purchasing queen bees. It is usually safe, however, to introduce a queen if she is removed from the cage in which she is mailed and is introduced unaccompanied by her escort of workers. The candy which is shipped with queens should never be put into a hive.

STRAY BEES.

There is one agent over which the bee keeper has no control and which should cause him no anxiety if a considerable territory is freed of the diseases. It is a well-known fact that under certain conditions, as, for instance, in storms and heavy winds, bees enter hives other than their own. Obviously, then, such bees in their interchange of hives may spread the infection. This only emphasizes the urgency of cleaning the disease out of a whole State, or, better, out of a block of States, as New England. Cooperation is the key to the situation.

BROOD DISEASES CAN BE CONTROLLED.

Enumeration of the methods by which disease is spread should not convey the idea that these diseases can not be combated, for it has been thoroughly demonstrated that by judicious and persistent manipulation both of them can be successfully controlled and suppressed. The rapidity with which they spread, however, makes cooperation of bee keepers throughout the State or States essential. Sixteen States and Territories[a] now have legislation and inspectors designed to protect the bee keepers from the spread of these infectious diseases. The State nearest to Massachusetts is New York, where the annual loss of bees alone is shown in the following figures:[b]

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[a] Report of the Meeting of the Inspectors of Apiaries, San Antonio, Tex., November 12, 1906. Bul. 70, Bur. Ent., U. S. Dept. Agric., 1907.

Previous to 1899, in a limited area, the loss of bees alone is estimated at	$39, 383
In 1899, when concentrated effort to suppress bee disease was begun, it amounted to	25, 420
In 1900	20, 289
In 1902	10, 853
In 1903 the loss of the previous year was halved, making it	5, 860
In 1903 it was	4, 741
In 1904 it was again divided by two, being	2, 220
In 1905 there was again a reduction of nearly 50 per cent	1, 725
Total loss of bees, covering about ten years	110, 491

In other States the encouraging results of inspection and persistent effort to suppress the inroads of disease are similar.

INSPECTION.

Inspectors are not alone police officers. They are educators, up-to-date bee keepers giving instructions in modern methods of bee keeping, thoroughly experienced in treating foul brood, and a great stimulus to progress. They are necessarily exacting and thorough; but they are not out to seize and condemn; their aim is to help the bee keepers, to assist them in a cooperative effort to eradicate disease, and to promote bee keeping. Of course the individual can do much for himself by keeping his own yard clean and free from infection; but he is in constant danger of reinfection from his neighbors, if they fail to cooperate with him.

A BRIEF ACCOUNT OF TREATMENT FOR BROOD DISEASES.

Those who are most experienced in the suppression of brood diseases are agreed that "shaking,"[c] which is practically "shook swarming," and modifications of this process are the only successful methods.

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[a] The legislation empowering this inspection in twelve of these States and Territories is reprinted from Bul. 61, Bur. Ent., issued November 5, 1906, and entitled "The Laws in Force Against Injurious Insects and Foul Brood in the United States," compiled by L. O. Howard and A. F. Burgess.

[b] These figures are afforded by a compilation made in 1905 by Mr. Charles Stewart from the records of the commissioner of agriculture of New York State.

[c] The various treatments are described by Dr. E. F. Phillips in Circular 79, of this Bureau, mentioned above.

SHAKING.

Shaking is briefly this: As soon as a colony is discovered diseased, and at a time when there would be no robbing, it is shaken on the old stand into a hive containing new frames with narrow strips of foundation. In this way none of the contaminated honey is deposited in the new cells. Should the disease reappear, which is sometimes the case, the operation must be repeated. In order to prevent the bees from swarming out, the queen may be caged in the hive for a few days or the entrance closed with a piece of queen-excluding zinc. Care should be taken not to scatter parts of the contaminated hive, particularly the honey, where bees can get at them.

DISINFECTION OF HIVE MATERIALS.

Honey, unless it has been boiled as above described, should never be fed back to bees. Wax, however, after being rendered and manufactured into foundation, is commonly used without apparent danger. It is customary in the East to put bees back into hives which have formerly contained diseased colonies, after they have been thoroughly cleaned of all bits of wax and honey. In the West, however, the hives are either burned out with oil, with a blue-flamed torch, or are disinfected with strong chemical disinfectants. All frames should be burned, since it does not pay to clean them.

U. S. D. A., B. E. Bul. 75, Part IV. A., December 26, 1908.

MISCELLANEOUS PAPERS ON APICULTURE.

THE RELATION OF THE ETIOLOGY (CAUSE) OF BEE DISEASES TO THE TREATMENT.[a]

By G. F. White, Ph. D.,
Expert in Bacteriology.

INTRODUCTION.

Bee keeping is not an industry which brings a fortune to a few, but is one the profits of which add comfort to 700,000 homes in America. This industry, which is a pleasure and a profit to so many, is beset with difficulties. One of the greatest obstacles encountered in the successful pursuit of bee keeping is disease. There are a number of diseases which attack the honey bee. Those which cause the greatest loss attack the brood. These diseases are known to the bee keeper as American foul brood, European foul brood, and pickled brood. Considerable loss is sustained also from paralysis and dysentery. Other disorders of less importance are sometimes encountered. If the apiarist is to treat these diseases effectively, he should become as familiar as possible with their etiology. Therefore this opportunity has been chosen to discuss the causes of bee diseases, as far as they are known, and to emphasize the importance of such knowledge in the treatment.

The word " disease " is made up of two parts, " dis," referring to a negative condition, and " ease," meaning a state of rest. By combining the parts we have the very appropriate word meaning a negative state of rest. We are all familiar with health, which is the state of rest. It is the condition which we experience when all the organs of the body are, so to speak, in a state of equilibrium. Any departure from this state of health is disease. You should remember that disease is alike in nature in all the animal kingdom and differs only in kind.

To understand best the nature of disease we must study the causes of disease. A number of factors may combine and be responsible for a diseased condition. This group of factors is known as the " etiology." Etiology, then, means the causation of disease. Let us further consider the etiology of disease and use bee diseases largely as illustrations.

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[a] Read at the meeting of the National Bee-Keepers' Association, Detroit, Mich., October 14, 1908.

ETIOLOGY (CAUSE) OF DISEASES.

Every abnormal condition in the body of an animal which we know as disease has a cause which has brought about such a condition. In most of the diseases of man and the higher animals comparatively little is known of the cause. Likewise, and unfortunately, the same is true of bee diseases. Gradually but slowly new facts about all diseases are added to our knowledge, the unfortunate thing being that so many statements are reported as facts which have never been demonstrated to be true.

In the study of the etiology of a disease and in the discussion of it, it is convenient to divide the causal factors into predisposing and exciting. Under the predisposing causes which may be considered as factors in bee diseases we have age, sex, race, heredity, climate, and preexisting disease. Under the exciting causes we may consider food and micro-organisms.

To illustrate, let us consider the different factors just mentioned.

PREDISPOSING CAUSES.

AGE.

In our experience with human diseases we have learned to expect scarlet fever, measles, mumps, and whooping cough more often in children than in adults; typhoid fever and appendicitis in young adults; and cancer in those more advanced in life. In bee diseases we expect European foul brood to attack larvæ that are younger than those which suffer from American foul brood. We expect the so-called "pickled brood" to die just before or after capping, while paralysis is, as far as we know, a disease of adult life.

SEX.

Of some importance in the etiology of human diseases is the factor sex. Inflammatory rheumatism, gout, and diabetes, for example, occur more frequently in men, while goiter and hysteria are more frequent in women. In bee diseases we expect in American foul brood to find the worker larvæ more often attacked than the drone, while in European foul brood this difference, if it exists, does so only to a slight degree.

HEREDITY.

You are all familiar with the fact that heredity is considered as an important predisposing factor in tuberculosis, cancer, gout, insanity, etc. It is interesting that in the so-called "pickled brood" there is some evidence which indicates that heredity plays an important rôle.

RACE.

Racial immunity is a rather interesting factor in the study of human and animal diseases. The negro, for example, seems to possess considerable immunity in gout and diabetes compared with the white race. Sheep ordinarily are very susceptible to anthrax, but there is an Algerian race of sheep which is immune to this disease. Some bee keepers believe that race is an important factor in bee diseases, but comparatively little is definitely known on this phase of the etiology.

CLIMATE.

That human diseases are more frequent in some climates than in others is a fact familiar to us all; that climatic conditions play a part in bee diseases seems to be quite probable.

PREEXISTING DISEASE.

Preexisting disease has very little, if anything, to do with bee diseases. By preexisting disease we mean that when an individual passes through an attack of a disease the disease predisposes that individual to other diseases. This is illustrated in various human and animal diseases. In bee diseases we do not know whether any larva or pupa ever recovers sufficiently from an attack of disease to continue its development and emerge as an adult bee. Many bee keepers think that adult bees in American foul-brood colonies are less active than in normal colonies. Whether or not they suffer from disease we do not know. It is possible, but not so probable, that they have suffered a light attack of disease while in the developmental stage and emerged as adult bees with weakened organs which do not perform a normal function. If this were true, it would illustrate the importance of preexisting disease as a predisposing factor in etiology.

Having thus briefly considered some of the more important predisposing causes which enter into the etiology of bee diseases, let us consider two of the more important exciting causes—food and micro-organisms.

EXCITING CAUSES.

FOOD.

The character of food is believed by many bee keepers to be an exciting factor in dysentery. Should the food contain poisons, grave results might follow. Some attribute paralysis to the character of the food, but this is far from a demonstrated fact.

MICRO-ORGANISMS.

By micro-organisms we mean those living plants and animals which are very small and must be magnified greatly before they can be seen. Those which are to receive our attention are bacteria, protozoa, and fungi.

Bacteria.—We have now come to the consideration of that factor in the etiology of bee diseases which is most important and with which we would have the bee keepers become familiar. The annual loss sustained by the bee keepers of this country due to the one cause, bacteria, is to be reckoned in millions. It is unfortunate that it is necessary to use the word bacteria, because too many at once think that they are not able to understand anything about bacteria. This is a mistaken idea. It is not difficult to understand the facts about them which are most important in the treatment of disease. It might be well to review here some of the things known concerning their life history.

Nearly two years ago the writer had the honor of reading a paper at a meeting of bee inspectors held at San Antonio, Tex., upon the subject of the bacteriology of bee diseases. This paper appears in Bulletin No. 70 of the Bureau of Entomology of the United States Department of Agriculture, page 10. In it are discussed briefly the nature of bacteria, their distribution, the methods of studying them, and the results of their activity. It is stated that bacteria—often called germs, microbes, and parasites—are very small plants; so small, indeed, that 12,000 placed end to end measure but 1 inch. They increase in number with marvelous rapidity. Under favorable conditions each bacterium in twenty minutes becomes two. At this rate countless millions are formed in twenty-four hours. As the soil becomes exhausted in which they are growing many species form spores which are in a way comparable to the seeds of higher plants. These spores are very difficult to destroy by heat and other disinfectants. It is well to remember, concerning the distribution of bacteria, that they are found in very large numbers everywhere about us, but that most of them are as harmless as the vegetables we eat. But should there be introduced into an apiary, for example, the species of bacteria which causes American foul brood, then the brood becomes exposed to the disease and will probably contract it.

The study of bacteria must be carried on for the most part in the laboratory. By the use of the microscope we are able to tell the genus (e. g., *Bacillus*) to which an organism belongs, and by specially prepared media, or soils, we are able to determine the species to which it belongs (e. g., *alvei*).

Having determined these things about bacteria, we are interested in finding out what they are capable of doing. We learn that some do good, as, for example, in bringing to decay the remains of dead animals and plants, while other species do harm by their ability to produce disease or death in the animals in which they are able to gain entrance. The disease American foul brood, which causes the greatest loss to the bee-keeping industry, has been demonstrated to be caused by bacteria. Above all, you should understand that the death of the brood is due to one species of bacteria growing in the larvæ.

Protozoa.—In contrast to bacteria, the protozoa belong to the animal kingdom. They are very small unicellular animals. Many species are harmless, as are many species of bacteria, while some species have the power to produce disease. They produce disease and death in a manner very similar to bacteria; that is, by growing in the body of a living animal. As far as we know, none of the bee diseases is due to protozoa. One investigator described what he thought was a protozoon and named it *Spirochæta apis.* It was shown that he made an error in his observations. Therefore there is no *Spirochæta apis* and no protozoon, as far as we know, which is pathogenic to bees.

Fungi.—The term "fungi" is a rather broad one, but in the diseases of animals we usually refer, in speaking of fungi, to those forms of plant life which are higher than bacteria. They are usually made up of branching mycelial threads, and have a variety of methods for producing spores. One writer described one species, *Aspergillus pollini*, which he was supposed to have proved to be the cause of pickled brood, but he had not done so.

To the above groups belong the known exciting causes. There are also unknown exciting causes. When the unknown causes become known they may be found to belong to the groups mentioned above.

There is a very important classification of diseases into those which are infectious and those which are noninfectious. From what has been said, this classification becomes clear to us. An infectious bee disease is one which may be transmitted from one colony to another through the natural processes in the apiary. American foul brood and European foul brood are examples of this class of disease. What is transmitted in an infectious disease? It is the exciting cause of that disease. In American foul brood it is one species of bacteria, *Bacillus larvæ.* In European foul brood we do not know what is transmitted. Since we do not know the exciting cause it must be classed under the unknown exciting causes. When the cause is determined it will probably be found to belong to one of the three groups of micro-organisms mentioned under the known causes. A noninfectious disease is one which is not transmitted from one colony to another. The so-called "pickled brood" and paralysis, as far as we know, illustrate this class of diseases.

This brief discussion of the etiology of disease is given in order that you may get a clearer idea of the nature of disease and what is meant by etiology. We shall now consider the treatment of disease and illustrate with bee diseases.

TREATMENT OF DISEASE.

The ultimate object in the investigation of diseases is the successful treatment of them. Before a disease can be treated rationally the diagnosis must be made; in other words, it must be determined what disease is present. If, for example, the so-called "pickled brood" is present in an apiary, the treatment will be quite different from what it would be if American foul brood or European foul brood were present; and if no disease is present, as sometimes happens, and the bee keeper suspects a disease, it is important that a positive diagnosis be made of this condition.

There is no method by which bee disease can be so positively diagnosed as by the finding of the exciting cause in the affected and dead bees. This fact is made use of in diagnosing samples of brood sent to the laboratory and illustrates one important advantage in knowing the etiology of disease. If we are to devise methods for treatment it is important that we should know where the exciting cause exists, under what conditions it grows, how it is carried from one place to another, and how it may be destroyed. These facts are determined by a study of the etiology of the disease, and it is upon such facts that we should base the treatment.

Those who are familiar with bee diseases are also familiar with the different methods of treatment. It is not the purpose of the writer to discuss any of the classical methods, but to suggest a few of the principles upon which such methods must be based if they are to be most effective. Treatment is both preventive and curative.

PREVENTIVE TREATMENT.

Too many believe that the treatment of bee diseases consists in the control or eradication of a disease after it is found in the apiary. This is only the minor part of treatment—the curative. The treatment which is of major importance is the preventive treatment. Prevention is much easier than cure. To prevent disease in the apiary is to keep it out. To keep it out is to keep out the exciting cause. In order to keep out the exciting cause, it is desirable to know its distribution or where it is found. In American foul brood the exciting cause, *Bacillus larvæ*, is found in immense numbers in the bodies of diseased and dead larvæ. These dead larvæ, for the most part, are allowed by the bees to remain in the brood cell as a scale. The honey also has been demonstrated to contain the bacteria which produce this disease. The pollen may be contaminated with the spores of this disease-producing organism. The combs from an apiary affected with American foul brood are a fruitful source of infection. The inside of the hives which have contained colonies suffering with American foul brood may be contaminated with the germs which cause the disease. Honey extractors, honey tanks, and wax extractors which have been used in infected apiaries are also a fruitful source of infection. Therefore if you are to keep the disease-producing bacteria out of your apiary, and thereby keep out disease, you must not feed honey unless you are positive that it did not come from an infected apiary or that it has been thoroughly boiled. Neither must you use old combs unless you are positive that they have not been in an infected apiary. Use no bee supplies from an infected apiary unless they are thoroughly disinfected.

These things being true of the infectious disease American foul brood, of which we know the cause, until the cause of any other infectious disease can be determined we can do no better than to suggest the use of the same principles in the treatment of such a disease as must be used in the successful treatment of American foul brood.

CURATIVE TREATMENT.

In the curative treatment, considering the colony as a unit, use is made of two widely different principles—the removal of the disease-producing material, thereby removing the germs, and the use of drugs.

In separating the disease-producing germs from the colony, all the combs are removed. This removes the principal sources from which the brood is infected—foul-brood larvæ and honey. It is always safer to allow the bees to go into a new hive or a hive which has been thoroughly disinfected. The greatest care should be exercised in protecting all infectious material which has been removed, that it may not be robbed by the bees.

The principle involved in the treatment by drugs is that of an antiseptic. The theory is that a small amount of some drug—like beta naphthol, salicylic acid, carbolic acid, eucalyptus, formic acid, etc.—is sufficient, when taken with the larval food, to inhibit the growth of the pathogenic bacteria.

Having thus in a general way considered the subject of the etiology of disease and the treatment in accordance with such knowledge, let us consider the different diseases separately.

AMERICAN FOUL BROOD.

That *Bacillus larvæ* is the cause of American foul brood has been demonstrated conclusively. It is a species of bacteria which when it is introduced into the healthy larvæ multiplies rapidly and causes the death of a large amount of the brood. When the larva dies the body decomposes and the remains dry down to a tongue-like scale on the lower side wall of the cell. In this scale are millions of spores which are able to produce disease in other larvæ should they be fed to them.

Just how the bacteria are carried from a dead larva to a healthy one we do not know. It is not uncommon, in examining the brood, to find only a portion of a larva in a cell, the bees having removed a part of it. When the body wall of a larva is broken in examining for foul brood, bees readily suck up the contents which flow out. This is true when the larva which is punctured is healthy, or when it is sick with disease, or after it has been dead a few days. The larvæ at these stages of the disease contain a very large number of the disease-producing bacteria. These observations would indicate that in this way, in part at least, the infectious material might be carried to healthy larvæ. Actual contact of the appendages of the bee with the foul-brood material, and the subsequent contact of the same appendages with the food of the larvæ, may be a method by which the disease-producing bacteria are spread. We do know that in foul brood it is possible to obtain *Bacillus larvæ* from the honey, and we do know that when bees are fed the spores of *Bacillus larvæ* in honey American foul brood will appear in the apiary.

The spores of this bacillus are very resistant to heat and other disinfectants. They resist the boiling temperature of water for fifteen minutes. In 5 per cent carbolic acid they were not killed in two months' time. This was demonstrated by obtaining growth in cultures after the spores had remained in this disinfectant for that length of time. Likewise it has been demonstrated that the spores of *Bacillus larvæ*, when taken from the scales of American foul brood, resist the action of mercuric chloride (corrosive sublimate), 1:1,000 aqueous solution, for two months. Having such facts before us, we can better judge the methods for treatment.

In treating this disease we must bear in mind the preventive and curative measures. In the preventive treatment many of the conditions you can control; others may be difficult. You can at least be sure that you import no bees or used supplies which might have been in an infected apiary. Use no old combs and feed no honey of which you do not know the history. In this way the bacillus which causes the disease in a large measure can be kept out of the apiary. There are conditions which are difficult to control. Should a near-by apiary be diseased and some of the colonies become weak or die out, it might be difficult for you, in a dearth of nectar, to keep your bees from robbing the diseased apiary and in this way bringing these disease-producing germs to your healthy colonies.

Some preliminary experiments have been made, but the results do not indicate that drugs, in the treatment of this disease, have the value advocated by some English writers.

EUROPEAN FOUL BROOD.

European foul brood is another infectious bee disease. It attacks the brood at an earlier period in the growth of the larvæ, as a rule, than American foul brood. The cause of this disease is not definitely known. From brood dead of this disease Cheshire and Cheyne isolated *Bacillus alvei*. From their work it was long supposed that *Bacillus alvei* was the cause of the disease, but later investigations make the value of their work doubtful.

A number of organisms have been found in the larvæ dead from this disease and some of them have been described. One species has been encountered in our investigations of the disease which is of special interest. The individuals of this species are quite small, apparently non-spore-producing, and have so far failed to grow when sown on our artificial media. Until we know more about this species it will be referred to as *Bacillus* "*Y*." Since the cause is not positively known, the amount of heat and chemical disinfectants to destroy the virus has not been demonstrated. If, later, *Bacillus* "*Y*" is demonstrated to be the cause, we shall expect that very much less heat will be sufficient to kill it than is necessary to kill *Bacillus larvæ*, the cause of American foul brood. Likewise we shall expect that chemical disinfectants will be much more readily effective. Until we know more about the etiology of European foul brood we can do no better than to suggest the application of the same principles which are found advisable in American foul brood.

SO-CALLED "PICKLED BROOD."

We refer to this disorder of the brood as the "so-called pickled brood" and not pickled brood, because the condition which William R. Howard, of Fort Worth, Tex., described is not what the bee keepers know as pickled brood. The exciting cause of this disease is not known. The larvæ die at that age just preceding or just after capping. Some bee keepers have a theory that heredity plays a very important part as a predisposing cause. As far as is known the disease does not seem to be infectious.

This disease is treated by some bee keepers by requeening, on the assumption that heredity is the important factor in the production of the disease. If more were known concerning the etiology, the treatment might be materially changed.

PARALYSIS.

Paralysis is a disease of the adult bee. The cause of this malady is not known. It does not seem to be infectious, although in some apiaries a large number of colonies may be affected at the same time. Some have advanced the theory that the character of the food is the exciting cause.

Since we know nothing positively about the cause, we can suggest very little in the way of treatment. The removal of the stores from the hive would tend to remedy the defect if the character of the food be an important factor in the etiology.

SUMMARY AND CONCLUSIONS.

We have now briefly considered the nature and the etiology of bee diseases and have suggested some of the principles upon which the methods of treatment must depend if such treatment is to be most efficient. If we review what we have just said concerning the etiology and treatment of the different diseases, we observe the following facts:

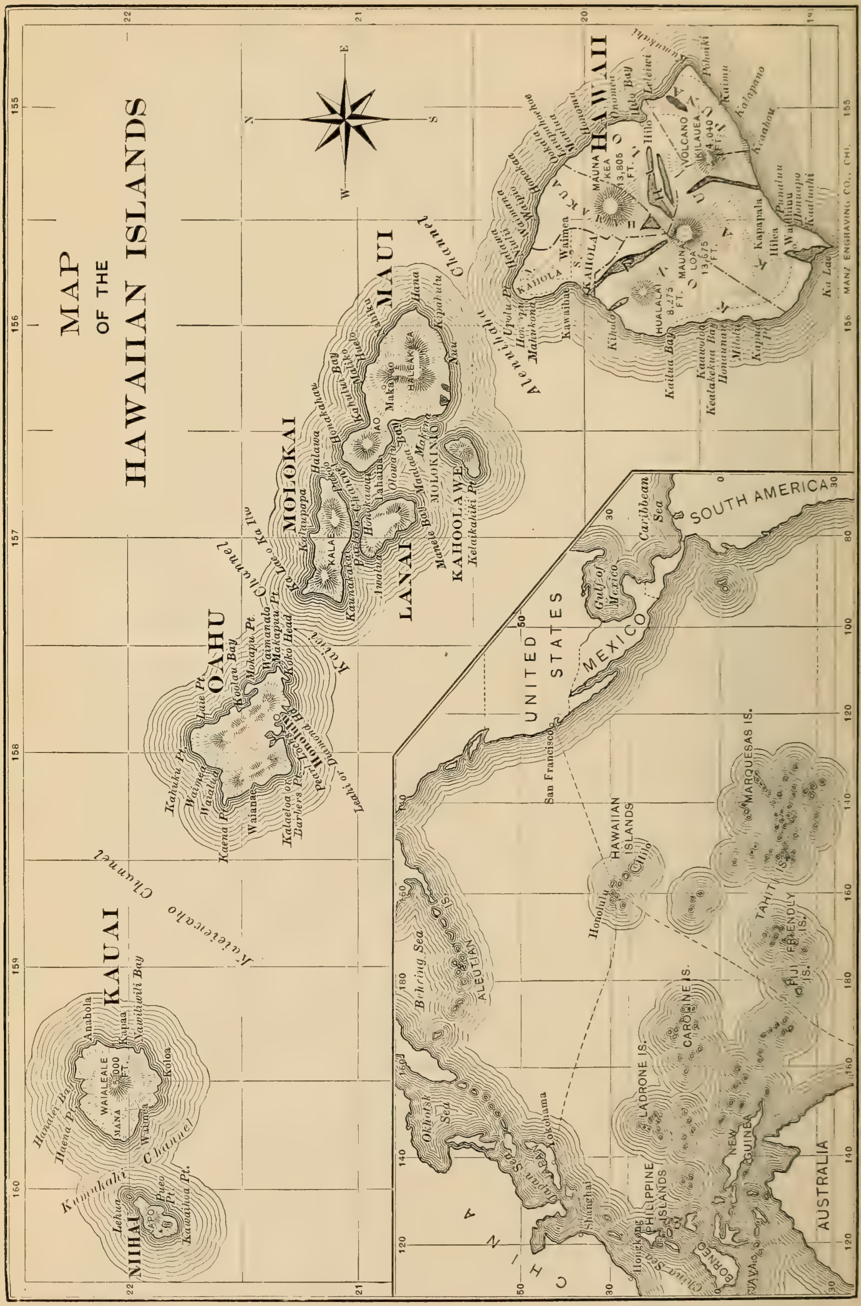
There is but one disease, American foul brood, of which we know absolutely the exciting cause. The cause is a species of bacteria, but there are many things concerning the nature, the distribution, and the activity of which we do not know. The facts which have been determined enable us to suggest some of the principles upon which the treatment must be based. Just so rapidly as our knowledge of the etiology of this disease increases, so rapidly will we be able to suggest principles for the improvement of the methods of treatment.

In European foul brood we only know positively that the disease is infectious, and we can do no better than to use the principles gained by the study of American foul brood. As our knowledge of the etiology of this disease increases, the methods of treatment will be altered.

In the so-called "pickled brood" we do not seem to have an infectious disease. Nothing is positively known of the etiology except that the larvæ die at approximately the same age in all cases, which is about the time of capping. The treatment that is used by some is based upon the principle that heredity is an important factor, and therefore requeening is resorted to.

In the disease of adult bees known as "paralysis," practically nothing is known and practically no treatment is known to be effective.

It will be noted that in every case the treatment of bee diseases is based upon the knowledge of the etiology. There are many things of very great importance in the etiology which are yet to be determined, but there are many things which are known that, if applied by the bee keeper, will prove to be of great value to him financially. It is to be hoped, then, that the bee keeper will make himself as familiar as possible with the nature of the etiology of bee diseases, since it is clear that the better the cause is known the better will be the treatment. From this discussion one conclusion can be drawn—that in the knowledge of the etiology of bee diseases lies the hope of their control.


MAP OF THE HAWAIIAN ISLANDS
KAUAI
NIIHAU
OAHU
MOLOKAI
LANAI
KAHOOLAWE
MOLOKINI
MAUI
HAWAII
Kaieiewaho Channel
Kaiwi Channel
Pailolo Channel
Alenuihaha Channel
Kaulakahi Channel
WAIALEALE 5,000 FT.
HALEAKALA
MAUNA KEA 13,805 FT.
MAUNA LOA 13,675 FT.
HUALALAI 8,275 FT.
VOLCANO KILAUEA 4,040 FT.
Honolulu
Hilo
Waimea
Koloa
Lahaina
Kailua Bay
Kealakekua Bay
Diamond Hd.
Koko Head
Pearl Lochs
Kaena Pt.
Kahuku Pt.
UNITED STATES
MEXICO
SOUTH AMERICA
HAWAIIAN ISLANDS
San Francisco
Gulf of Mexico
Caribbean Sea
Behring Sea
ALEUTIAN IS.
Okhotsk Sea
Japan Sea
Yokohama
Shanghai
Hongkong
China Sea
CHINA
PHILIPPINE ISLANDS
LADRONE IS.
CAROLINE IS.
MARQUESAS IS.
TAHITI IS.
FRIENDLY IS.
FIJI IS.
NEW GUINEA
BORNEO
JAVA
AUSTRALIA
MANZ ENGRAVING CO., CHI.

MISCELLANEOUS PAPERS ON APICULTURE.

A BRIEF SURVEY OF HAWAIIAN BEE KEEPING.

By E. F. PHILLIPS, Ph. D.,

In charge of Apiculture.

INTRODUCTION.

Bee keeping on the Hawaiian Islands is one of the minor industries which is being conducted with profit. As in all other places, this business can never, from its very nature, become a leading industry, but there is reason to believe that there is yet room for considerable expansion. The modified methods made necessary by a tropical climate and other conditions of a local character present some new phases of the keeping of bees, and in view of the fact that these modifications will be of interest to bee keepers on the mainland, as well as to those in Hawaii, it seems desirable to put on record a brief account of what the author was able to observe personally and to learn from others in the four weeks spent on the islands in making an apicultural survey.

The author would express his thanks to the bee keepers of the islands for the cordial way in which they anticipated his every desire in planning the trips of investigation. He would also mention the particular assistance of Mr. D. L. Van Dine, entomologist of the Hawaii Agricultural Experiment Station, who accompanied him on all his trips, and from whom much of the information in this paper was gathered.

PUBLICATIONS ON HAWAIIAN BEE KEEPING.

Different phases of Hawaiian bee keeping are discussed in other publications, a list of which is appended.[a] The bee keepers of the islands have been extremely fortunate in enlisting the interest of the Hawaii Agricultural Experiment Station. Mr. D. L. Van Dine, the entomologist of the station, has been very active in rendering valuable assistance to the bee-keeping industry by his investigations, and Miss Alice R. Thompson, the acting chemist, has done good work in chemical analysis of honeys.

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[a] Reports of the Royal Hawaiian Agricultural Society (1851–1856).

A Brief History of the Hawaiian People, by W. D. Alexander, 1899, p. 286.

Report of the Entomologist, by D. L. Van Dine, in Report on Agricultural Investigations in Hawaii, 1905, by Jared G. Smith. Bulletin 170, Office of Experiment Stations, U. S. Dept. of Agriculture, 1906.

Report of the Entomologist, by D. L. Van Dine, in the Annual Report of the Hawaii Agricultural Experiment Station for 1907, 1908.

Introduction of Honey-Producing Plants, by D. L. Van Dine; Hawaiian Forester and Agriculturist, Vol. V, pp. 9–13.

Hawaiian Honeys, by D. L. Van Dine and Alice R. Thompson. Bulletin 17, Hawaii Agricultural Experiment Station, 1908.

Chemical Analysis and Composition of American Honeys, by C. A. Browne, including a Microscopical Study of Honey Pollen, by W. J. Young. Bulletin No. 110, Bureau of Chemistry, U. S. Dept. of Agriculture, 1908.

BEE-KEEPERS' ASSOCIATION.

The bee keepers of Hawaii are organized into an active and efficient association, which has been in existence about two years. By united effort this organization has accomplished much that is of great value to the industry. When the question of marketing their honey under the regulations of the food and drugs act of 1906 arose they sent a representative to Washington to present their case. In this and many other ways the bee men have shown themselves to be alert and progressive in looking after their best interests.

METHODS OF MANAGEMENT.

At the present time bee keeping is largely in the hands of four corporations, they owning and operating at least four-fifths of all the bees on the islands. These companies are all managed by American citizens, but there are a number of smaller apiaries, some of which are owned by Japanese. The last-named apiaries are usually not so well kept nor are they so productive. The total number of colonies at present is probably about 20,000, and the annual output of honey, which is mostly shipped to the mainland or to Europe, is probably about 600 tons.[a] The keeping of bees by corporations, as opposed to individual ownership, is something which is rarely observed elsewhere. As they are located a considerable distance from the market and as the expense of supplies and shipping is high, it has seemed desirable to the bee keepers to organize companies so that they may make large shipments. There is also on the Hawaiian Islands a tendency, to a marked degree, to incorporate all industries, and doubtless the prevalence of this method of conducting business has induced the bee keepers to adopt it also. With this system it is possible for one skilled manager to oversee the manipulation of several thousand colonies, the actual manipulation being done in most cases by the Japanese helpers; in this way the cost of maintenance of the apiaries is reduced very considerably. Since the price obtained for Hawaiian honey is still rather low, it is of course necessary to reduce expense in every way possible.

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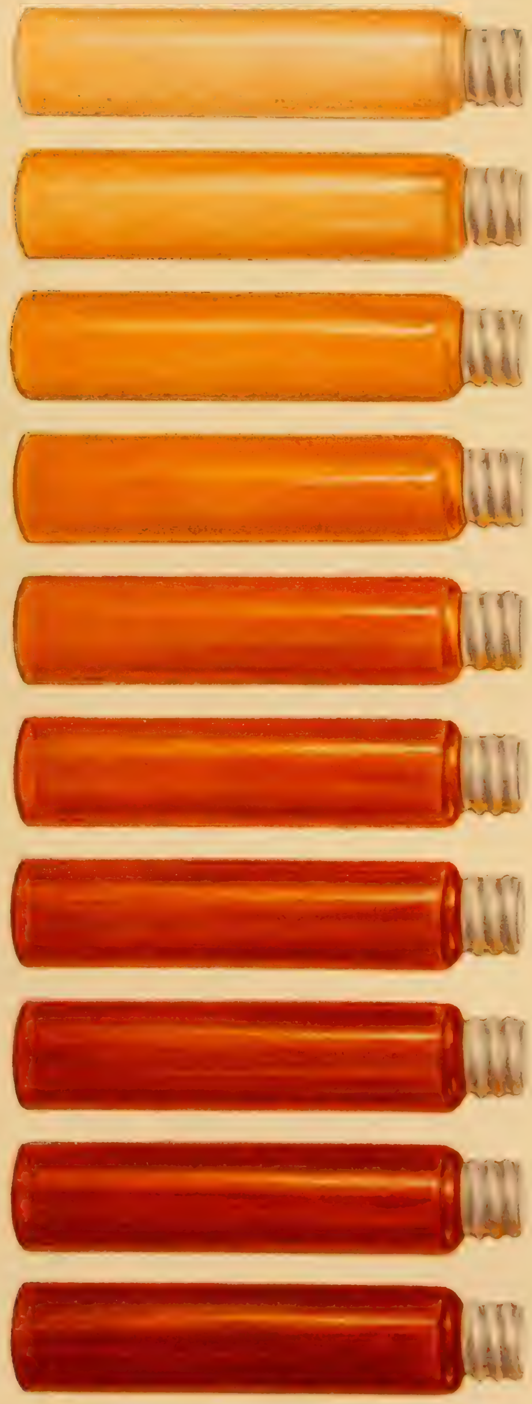
[a] The crop for 1908 will probably amount to nearly 1,000 tons, according to a recent report from the entomologist.



BLENDS OF ALGAROBA HONEY AND HONEYDEW FROM THE HAWAIIAN AGRICULTURAL EXPERIMENT STATION.

[PLATE I, BUL. 110, BUREAU OF CHEMISTRY.]

"BEE RIGHTS."

The buying of "bee rights," as it is practiced in Hawaii, is something practically unheard of elsewhere, and would certainly appear to a mainland bee keeper as a new and strange procedure. The nearest approach to it is the renting of locations for outyards, which can not usually insure no competition. This practice would not be possible were it not for the fact that most of the available agricultural land on the islands is held in large tracts, mostly as sugar-cane plantations and ranches. Arrangements are made with the manager of a plantation for locations for apiaries, and the bee keeper agrees to pay a certain amount for the use of the land and for the honey removed from these apiaries. Frequently this is in the form of an agreement to pay a certain sum for each ton of honey removed from the plantation, but at times it is a fixed sum for the year, the bee keeper assuming what small risk there is of not getting a crop. The plantation management in turn agrees to allow no other bee keepers to keep bees in its territory. There are frequently small holdings within the boundaries of the plantation over which the plantation company has no control, and some other bee keeper may lease these with the idea of allowing his bees to range over the entire plantation. If, for example, he puts 200 colonies on such a holding, the immediate placing of say 500 colonies just across the line has a discouraging effect on this poaching and it can end in only one way, since the bee keeper who has a right there has the advantage. The same thing happens when an outside bee keeper gets too close to the boundary line.

Naturally, when land is divided into smaller holdings, as is the case almost everywhere on the mainland, such an arrangement is not possible and a bee keeper must run the risk of competition. There is no way of telling what amount of honey is taken from any given area when the tracts are small. The moral right of priority claim, which so many bee keepers advocate, has small place in the manipulations of territory in Hawaii, where the bee-keeping companies pay for what they get and insist on getting it. One of the large companies gains its exclusive right by reason of the fact that it owns and leases a tract of over 100,000 acres for ranch purposes.

EXTENT OF THE INDUSTRY.

At the present time there are on the islands probably about 20,000 colonies of bees, most of which are, as above stated, owned by four companies. From the custom-house statistics it is shown that the annual shipments of honey amount to about 1,000 tons. The island of Kauai now supports about 3,000 colonies, and, after traveling over almost the entire cultivated portion of the island, the author is of the opinion that the island is just about half stocked. The island of Oahu seems to be well covered from an apicultural standpoint. Molokai is not a cane-producing island, but the algarroba forest is nearly stocked, and the only place for heavy expansion seems to be in the mountains, where several forest trees are nectar bearing. The island of Maui could not be examined as carefully as the others on account of inclement weather, but from reports received it is obviously not stocked to the extent that it should be. The island of Hawaii, the largest of the group, is relatively the least developed of any of the islands. There are only a few apiaries on this area, which is almost equal in extent to Connecticut, and there are great possibilities. On the south coast there are vast areas of cane, and the same is true of the Hamakua coast on the north. The Kona coast would probably support some bees in the coffee plantations. One such apiary was seen by the author (Pl. VII, fig. 2). On the interior of the island there are vast areas which are entirely undeveloped from an apicultural standpoint, and the island can doubtless support thousands of colonies of bees at a profit.

The total area now actually stocked with apiaries would not nearly equal in size one-half the State of Rhode Island, while the honey crop is probably 20 times as great as in that State. According to the Census Report for Rhode Island it would be 40 times as great, but we can not use this figure on account of its obvious unreliability. This comparison will show the honey-producing capabilities of the islands as compared with our more northern countries, and will also show how thoroughly the areas are stocked where the industry has been taken up. A small part of Oahu is doubtless overstocked, due to crowding into a given area by competitive companies. There was no evidence of such overstocking elsewhere.

Overstocking an area with bees is a subject much discussed among bee men, and the situation in Hawaii illustrates very beautifully the fact that a theoretical discussion of how many colonies may be kept in one place is of no value whatever. Each location must be judged on its own merits, and a given area which will support only 20 colonies in one region may support 1,000 elsewhere. It is also obvious that seasons vary to a marked degree. In many parts of the mainland it is deemed advisable to keep not more than 100 colonies in one apiary and to allow each apiary a radius of 1½ to 3 miles. On the basis of these figures, from 50 to 200 acres are necessary to support a single colony of bees. Without discussing the merits of these figures, it is enough to say that this is the common mainland practice, particularly in the more densely populated areas. In contrast to this, an examination of the methods in Hawaii is extremely significant. One area of cane on the island of Oahu contains a little over 20,000 acres. As will

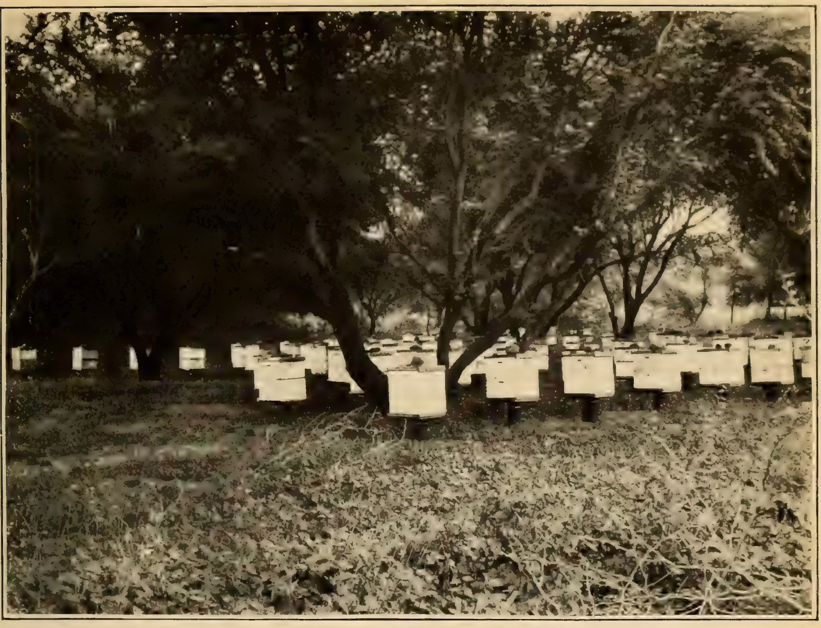


FIG. 1.—A TYPICAL HAWAIIAN APIARY, THE HIVES ON STANDS TO PREVENT ANT ATTACKS. (ORIGINAL.)

FIG. 2.—AN APIARY IN A COFFEE PLANTATION. (ORIGINAL.)

be discussed later, this is not all equally productive from a bee-keeping standpoint. Near this is some algarroba forest, but not enough to influence the crop very much. This area supports nearly 5,000 colonies, some of which yield exceptionally large crops. In certain parts of this area competition is too strong to yield proper results, but some apiaries yield over 200 pounds to the colony. In some other cane areas this record can be almost equaled. Algarroba will not produce so much per acre, but this is partly due to the fact that it blooms for less than six months, while cane fields furnish honeydew every day in the year. One strip of algarroba forest on Molokai supports nearly 2,000 colonies. It will not average more than one-half mile in width, and about 30 miles of it is used for bees.

SOURCES OF HONEY.

FLORAL HONEY.

The amount of floral honey produced on the islands annually is about 200 tons. Formerly the only source of honey on the islands which was widely enough distributed to make bee keeping commercially important was algarroba, native "keawe." (Pl. VIII, fig. 1.) This tree was introduced into the islands by Father Bachelot, founder of the Roman Catholic mission, in 1837, and the original tree still stands on Fort street, in Honolulu. It has been carried to all the islands and is one of the most valuable plants ever brought into the group. It furnishes not only an excellent honey, but the pods afford excellent fodder and the wood is the main source of fuel.

The honey from algarroba is "water white" in color and granulates very soon after it is stored by the bees in spite of the warm climate of the islands. This characteristic makes frequent extractions necessary to prevent the combs from being clogged. In regions where algarroba is practically the only source of honey, at the close of the flow an amount of honey sufficient to keep up the colony until the next flow is left in the hive. This, of course, soon granulates. When the honey flow diminishes, the brood chamber is reduced and considerable honey is stored in the space formerly occupied by brood. When the next flow comes on, a good deal of this granulated honey remains in the combs, and since this can not be extracted, these combs are removed and replaced either by empty combs or by foundation, to give the queen more room. These combs containing granulated honey are then placed in huge solar extractors, the largest that the author had ever seen. With 200 or more colonies in an apiary, there is often need for a solar extractor which will hold several hundred combs at a time, and practically every apiary visited by the author had such a piece of apparatus as part of the equipment. The sun's heat liquefies the honey and melts most of the wax, and the wax from the "slumgum" is then extracted by the usual methods. The honey from these solar extractors is not darkened, as one would expect.

The algarroba tree (*Prosopis juliflora*) is either the same species as or very closely related to the mesquite of the southwest. On the islands it grows to the size of a tree, as is also the case in Mexico. In Texas it is generally very much smaller. In 1908 the tree came into bloom about the 1st of March, the time varying considerably in different localities on the islands. It usually blooms until August, and this very long blooming period adds greatly to its value to the bee keepers.

The following list of honey plants, other than algarroba, is furnished by Mr. D. L. Van Dine, entomologist of the Hawaii Agricultural Experiment Station. Mr. Van Dine has studied the honey sources of the islands very thoroughly. Many of these plants were pointed out to the writer while he was on the islands.

FOREST TREES.

Texas mesquite (*Prosopis glandulosa*). Growing in dooryard of Mr. C. C. Conradt, Pukoo, island of Molokai. Seeds under propagation at Hawaii Agricultural Experiment Station. Introduced by Mr. Conradt from Texas several years ago.

Ohia lehua (*Metrosideros polymorpha*). Produces a particularly high grade of honey. Locations for apiaries as a rule somewhat inaccessible. One location on the island of Molokai is within the ohia lehua belt.

Various species of Acacia (black wattle, koa, etc.). Mountainous districts.

Various species of Eucalyptus. Mountainous districts.

Wiliwili (*Erythrina monosperma*). In gulches on Molokai and Oahu.

Rose-apple (*Eugenia jambos*).

Mamani (*Sophora chrysophylla*). Found in higher forest belts.

Catalpa (*Catalpa speciosa* and *C. bignonioides*). Introduced by Mr. Jared G. Smith, April, 1902, from the Missouri Botanical Gardens. The seeds were distributed to L. von Tempsky, Makawao, and H. P. Baldwin, Puunene, on Maui; to S. M. Damon, Moanalua Gardens, on Oahu; to Francis Gay, Makaweli, on Kauai; and to Louisson Brothers and Albert Horner, Hamakua, and B. B. Bond, Kohala, on Hawaii. The seeds were sent to the above-named parties under date of April 10, 1902. No reports are on file at this station as to the results of this introduction.

Logwood (*Hæmatoxylon campechianum*). Found in dooryards. Two trees are growing in the grounds of Oahu College and one in the grounds of Lunalilo Home, Honolulu. Seeds under propagation at Hawaii Agricultural Experiment Station. The honey produced by bees from this tree is reported to be the finest table honey in the world. The propagation and distribution of the logwood throughout the Territory would be of great value to bee keepers. The wood furnishes the logwood dye of commerce.

The black mangrove of Florida. Introduced by Mr. Jared G. Smith from southern Florida, for the purpose of preventing the mud flats from washing, along the coast of Molokai near Kaunakakai. The introduction was made several years ago and the trees are now well established at the above-mentioned place. The tree is a valuable honey plant. The station is now trying to secure the Philippine mangrove, a tree suitable for similar locations but possessing greater value as a timber tree.

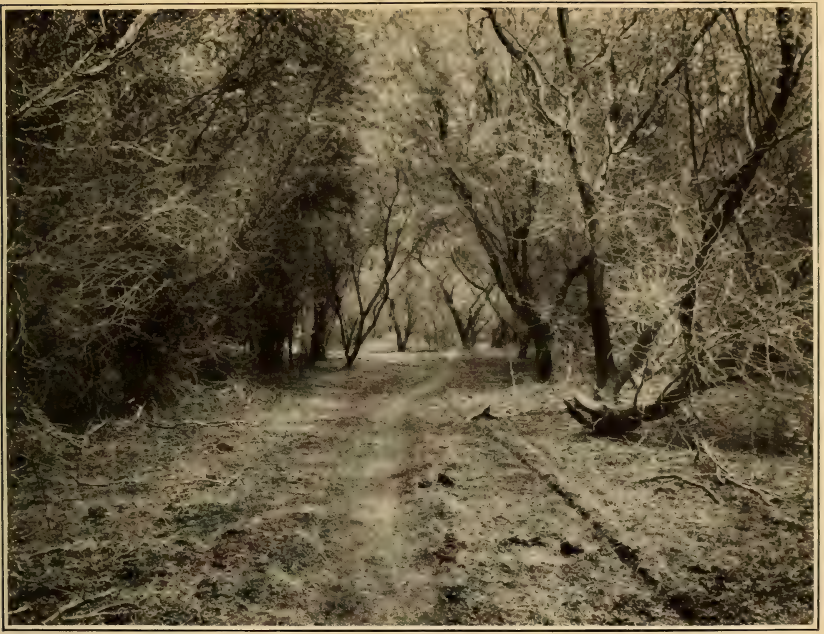


FIG. 1.—PART OF AN ALGARROBA FOREST. (ORIGINAL.)

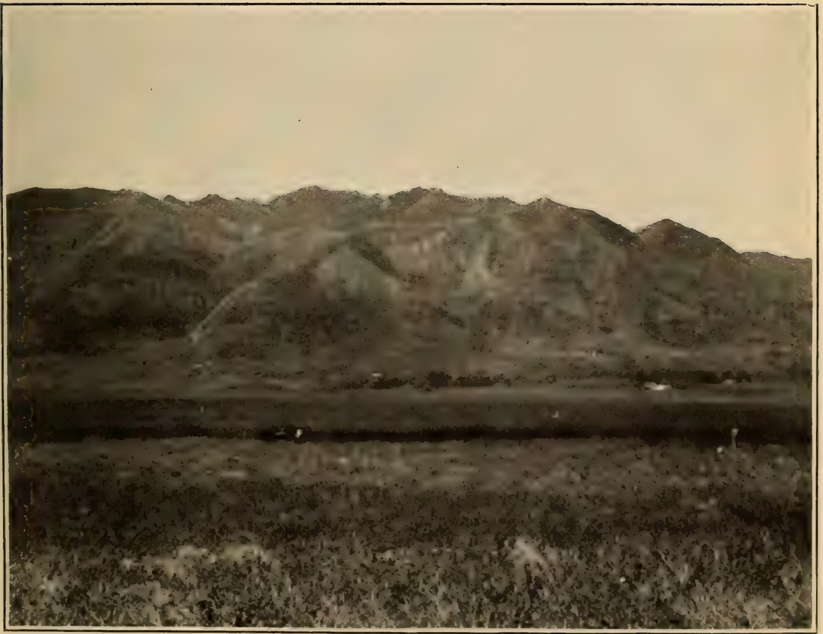


FIG. 2.—A LANTANA JUNGLE. (ORIGINAL.)

FRUIT TREES.

Various species of Citrus (orange, lemon, lime, etc.).

Avocado (*Persea gratissima*).

Banana (*Musa* spp.).

Guava (*Psidium* spp.).

Loquat (*Eriobotrya japonica*).

Tamarind (*Tamarindus indica*).

PASTURE PLANTS.

California burr-clover (*Medicago denticulata*). Introduced on Maui in 1882 by Mr. C. R. Blacow. Now found generally on the ranches of the islands.

Carpet grass (*Lippia repens*). Growing on grounds of Hawaii Agricultural Experiment Station.

Alfilaria or filaree (*Erodium cicutarium* and *E. moschatum*). Seeds introduced in California hay. Established on upland pastures on Hawaii and Molokai.

White clover (*Trifolium repens*). Found on Haleakala and Makawao pastures, Maui.

CROP PLANTS.

Sisal (*Agave sisalana*).

Various species of cucurbits (melons, squashes, pumpkins, cucumbers, etc.).

FORAGE PLANTS.

Alfalfa, several varieties.

Lupine, blue and yellow. Occasionally used as green manure plant on sugar plantations.

Tangier pea (*Lathyrus tingitanus*). Growing at Haiku, Maui.

Sanfoin (*Onobrychis sativa*). A forage plant introduced by Mr. Jared G. Smith in 1904. Seed distributed to ranches.

ORNAMENTAL PLANTS.

Palms, particularly the royal and cocoanut.

Poppy, a horticultural form of *Romneya coulteri*, found in gardens in Honolulu.

Chinese ink-berry (*Cestrum diurnum*).

Thevetia neriifolia.

Vines (*Ipomœa* spp.).

WEEDS.

Lantana, two species. (Plate VIII, fig. 2.)

California sages (*Artemisia*). Introduced by Hawaiian Bee Keepers' Association in 1907. Not as yet established. Suitable for waste, arid lands. The most important honey plant in California. Valuable as a forage plant.

Ilima (*Sida* spp.).

Oi (*Verbena bonariensis*).

Pili grass (*Heteropogon contortus*).

Spanish needle (lauki) (*Bidens pilosa*).

Puakala (*Argemone mexicana*).

Alii (*Dodonæa viscosa* var. *spathulata*).

Hila hila (undetermined).

Other weeds are *Waltheria americana*, *Ipomœa pes-capræ* (vine along sea coast), and *Malvastrum tricuspidatum*.

OTHER SOURCES OF HONEY.

Insect honeydew.—Hawaii is peculiar in that most of the honey produced is from some source other than flowers. Two-thirds of the honey shipped annually from the islands is largely or entirely honeydew honey. By far the greater part of this comes from the exudations of the sugar-cane leafhopper (*Perkinsiella saccharicida* Kirk.) and possibly some of it from the sugar-cane aphis (*Aphis sacchari* Zehnt.), although while on the islands the author observed none of the latter species. (See Pl. IX, fig. 1, showing an apiary near a field of sugar cane.) Of course, in a tropical country there are many other insects producing more or less honeydew. The young "plant cane" is most abundantly covered with leafhoppers.

Honeydew from the sugar-cane leafhopper is very dark amber in color and slightly ropy. In flavor it very strongly resembles molasses from the cane juice. Since the color and flavor are so marked, a small amount of this when mixed with the mild, light-colored algarroba honey imparts the color and flavor of honeydew to the entire amount. Most honeydew honeys on the mainland granulate very rapidly, but this type does not granulate at all. Samples several years old are as clear as when first extracted.

The chemical composition[a] of Hawaiian honeydew honey is quite unlike that of floral honey, and this fact has led to the charge of adulteration by buyers on the mainland and in foreign markets. Since nowhere else, as far as the author is aware, is honeydew honey produced in such large quantities, it is not strange that cursory examinations were misleading. The author saw enough while on the islands to convince him that, however unlike floral honey this product may be, it is a natural sweet product collected and stored by the bee and is then extracted and shipped with no additions of other sugars.

When the food and drugs act of 1906 went into effect the Hawaiian Bee Keepers' Association sent a representative to Washington to find out under what name they could market their crop, since it does not conform to the standard of the Association of Official Agricultural Chemists. They were informed that it could be sold on the mainland market provided it were labeled just what it is. This

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[a] *Chemical composition of Hawaiian honeydew honey made from sugar-cane honeydew.*

[From Bulletin No. 110, Bureau of Chemistry, p. 37.]

Polarization.						Complete analysis.						Free acid as formic.	Reducing sugars as dextrose.	Remarks.
Direct.			Invert.											
Immediate, 20° C.	Constant, 20° C.	Birotation.	20° C.	87° C.	Difference.	Water.	Invert sugar.	Sucrose.	Ash.	Dextrin.	Undetermined.			
+24.9	+17.75	7.15	+13.53	+34.76	21.23	15.46	64.84	5.27	1.29	10.01	3.13	0.15	62.1	High in chlorid.

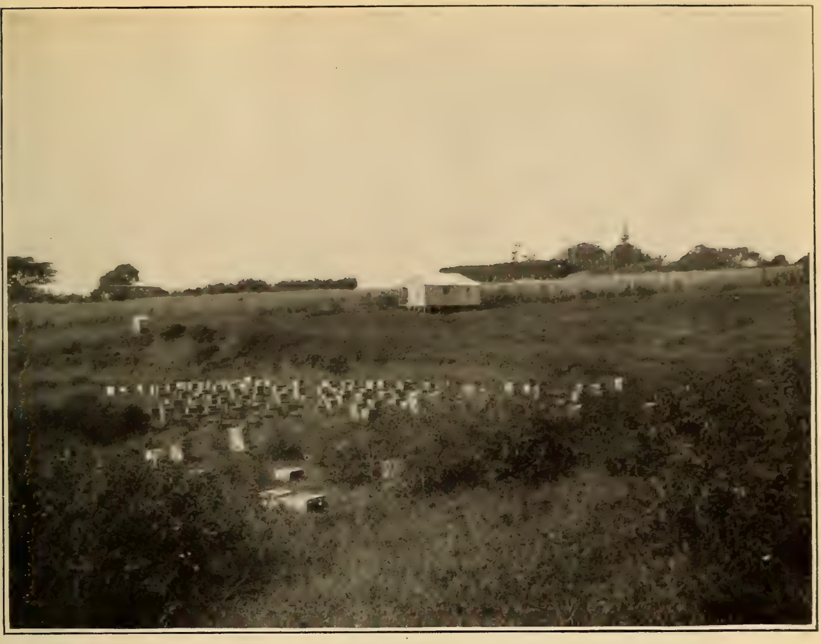

FIG. 1.—AN APIARY NEAR A SUGAR-CANE FIELD. (ORIGINAL.)

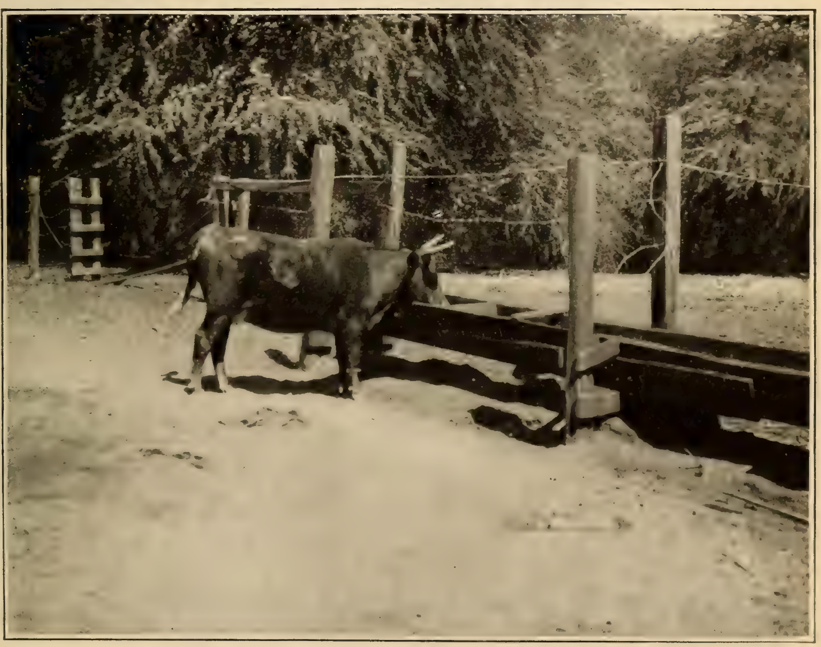

FIG. 2.—MOLASSES TROUGH FOR FEEDING CATTLE. (ORIGINAL.)

the Hawaiian bee keepers have done and it is now sold as "honeydew honey." The bee keepers of Hawaii fully realize the peculiar honey with which they have to deal and are not attempting to market honeydew honey in competition with floral honey for table use. It goes to the baking trade and for such use is reported to be satisfactory; at any rate, the price received is equal to that received for algarroba honey.

As stated elsewhere, bees prefer floral nectar to honeydew. However, when the supply of floral nectar is not great, the bees work on both, and as a result there are mixtures of the two, stored in the hives, varying all the way from the pure honeydew honey to pure floral honey. It is these mixtures that cause the trouble in labeling. One of the requisites of a pure honey as defined by the standards[a] is that it shall be lævorotatory to polarized light; hence, since honeydew honey is dextrorotatory and there are blends made by the bees of this and algarroba honey, it is necessary to have a chemical analysis made to be absolutely certain whether a given quantity of the product of the islands may be sold as honey or as honeydew honey. The various mixtures which occur are well illustrated in Plate I of Bulletin 110, Bureau of Chemistry, here reproduced as Plate VI. This plate illustrates very well the influence of honeydew on the physical properties of honey. At one end of the series is the pure algarroba, which is represented as granulated, while at the other end is a sample of honeydew honey which is as pure as it is usually found. Between the two in perfect gradation are shown various mixtures just as they came from the hive in various extractings. The chemical analyses of these particular samples, made by Miss Alice R. Thompson,[b] show that the chemical composition varies in exactly the same way. Of these samples, Doctor Browne[c] says:

> From the polarizations and analyses of these samples (as given in the table) it will be seen that there is a range in direct polarization from —22.0 to

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[a] U. S. Dept. Agr., Office of the Secretary, Cir. 19, p. 11.

[b] *Polarization and analyses of honeydew blends.*

[From Bul. 17, Hawaii Agr. Exp. Sta.]

Data.	Algarroba honey.	Blends.								Honeydew.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Polarization direct (°V)	−22.00	−18.3	−14.3	−8.7	−0.3	+0.5	+4.0	+8.9	+19.2	+24.5
Polarization invert (°V)	−27.61	−21.4	−17.3	−11.5	−3.8	−4.2	−1.0	+3.2	+12.4	+15.3
Sucrose (per cent)	3.58	2.4	2.3	2.2	2.7	3.7	2.3	4.5	5.3	7.2
Reducing sugar (per cent)	76.84	76.64	77.28	72.36	65.56	66.16	67.28	63.08	58.92	59.76
Ash (per cent)	.34	.58	.69	.72	1.06	1.11	1.12	1.33	1.77	2.04
Nonsugars (per cent)	1.41	1.67	1.81	7.17	13.52	12.09	11.84	15.27	17.68	15.88

[c] Bul. 110, Bureau of Chemistry, pp. 55–56.

+24.5; in ash, from 0.34 per cent to 2.04 per cent; in reducing sugars, from 76.84 per cent to 59.76 per cent; and in organic matter not sugar, from 1.41 per cent to 15.88 per cent. In sucrose also there is an irregular increase from 3.58 to 7.2 per cent, this increase becoming more regular as soon as the quantity of honeydew is sufficient to mask the variation in sucrose content of the individual honeys in the series of blends. The granulation of the blends decreases with the increase of honeydew and ceases at about the point of optical inactivity. The latter point, as has been said, is taken by the chemist as the arbitrary dividing line between normal and abnormal honeys, and bee keepers in the Hawaiian Islands who are troubled with honeydew have in the matter of granulation a rough guide for the classification of their product. If the honey granulates, it may be put in the normal class; if it remains liquid for any length of time, it probably belongs to the class of honeydews. This statement does not apply in general to mainland honeys.

The dextrorotatory honeydew honeys can not be regarded as adulterated, in the strictest sense of the word; nevertheless they are frequently so pronounced by chemists, who, in the general work of routine, are often satisfied with a most superficial examination, and regard dextrorotation or high ash content as certain evidence of adulteration.

There is a test which may be applied with considerable safety. Algarroba honey granulates rapidly and pure honeydew honey does not; it has been found by analysis that mixtures which granulate are as a rule of such a chemical composition that they may be sold as honey. The flavor and color may be characteristic of honeydew honey in spite of the fact that the mixture contains enough floral honey to be sold as such.

The sugar-cane leafhopper was first collected on the islands by Dr. R. C. L. Perkins, now connected with the Hawaiian Sugar Planters' Agricultural Experiment Station, in 1900,[a] and by February or March of 1903 had "appeared generally throughout the cane fields of Hawaii in numbers sufficient to prove a serious check to the growth of the cane."[b] For several years the work of this insect caused a loss of about $3,000,000 annually[c] to the planters, and naturally they were anxious that something be done to stop this heavy loss. By various means the leafhopper has been brought under control until to-day it is not abundant enough to hinder the growth of the plants, "and plantations that were to a certain extent abandoned are again producing heavy crops of sugar."[d]

During the time spent on the islands the author saw no sugar-cane fields that were seemingly injured by the leafhopper, but, on the other hand, there were no cane fields examined that did not contain many leafhoppers. The fact that the leafhopper is not doing damage enough to hinder cane raising does not signify that it has disappeared, nor is there any biologic reason for believing that it will, while cane is grown, unless some entirely new methods of fighting it are found. The fact that 400 tons[a] of honeydew are produced annually from this source in spite of the fact that only a limited amount of the cane area is accessible to bees is a certain indication of the untold millions of these insects which still exist.

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[a] The Leaf-Hopper of the Sugar Cane, by R. C. L. Perkins. Bulletin No. 1, Division of Entomology, Board of Commissioners of Agriculture and Forestry, Territory of Hawaii, 1903.

[b] The Sugar Cane Leaf-Hopper in Hawaii, by D. L. Van Dine. Bulletin No. 5, Hawaii Agricultural Experiment Station, 1904.

[c] Report of the Governor of Hawaii to the Secretary of the Interior for the fiscal year ending June 30, 1907, p. 22.

[d] Ibid.

The leafhoppers exude a sweet, gummy substance on the leaves of the cane and the honey bees work on this eagerly. However, where bees have access to both honeydew and floral nectar, they prefer the nectar to a marked degree. When algarroba begins to bloom the honey stored becomes noticeably whiter.

In view of the fact that honeydew honey has the taste and color of common molasses, it has been suggested that probably this product is gathered by the bees from the sugar mills which are so numerous on the islands. The writer visited several such mills located near apiaries on days when bees were actively flying. No bees were to be seen anywhere around the mill. If bees actually did come to the mill after sweets, they would become a serious nuisance to the workmen. Why they do not is something of a mystery to the writer, but he can vouch for the fact that he saw no mills screened to keep bees out, nor did he see any bees at work in the mill or even on the pile of sweet refuse ("mud cake") outside.

Molasses is used quite extensively for feeding cattle on the islands. It is poured out in troughs or half barrels where the cattle can get it easily, and frequently these are located near apiaries. Many of these were examined as the writer went about among the apiaries, and in not a single instance did he ever see a bee at work on the molasses. In some cases these feeding troughs are as near as a quarter of a mile to apiaries. A dairyman near Waimea, Kauai, whose trough (Pl. IX, fig. 2) is located not a quarter of a mile from a large apiary, informed the writer that he had never seen bees working on the molasses. Obviously, Hawaiian honeydew honey does not come from this source.

Extra-floral plant honeydew.—The situation in Hawaii as regards sources of honey is made still more complicated and interesting by the fact that the hau tree (*Paritium tiliaceum*) has nectaries on its leaves which secrete a honeydew. These are located on the veins of the leaves near the stem and are one, three, or five in number. Small drops of honeydew may frequently be seen on these spots. It is interesting to note that these extra-floral nectaries are present on the outside of the calyx of the flowers. There is apparently no true floral nectary.

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[a] Five hundred tons in 1908.

The hau tree is used quite extensively as a hedge, and grows from 20 to 30 feet high (Pl. X, fig. 1). It is doubtful whether this is the source of any great percentage of the honeydew honey, but the fact that it is present makes it still more difficult to analyze the bee-keeping situation on the islands.

INTRODUCTION OF HONEY PLANTS.

In addition to the nectar-secreting plants now found on the islands, either as native plants or as recently introduced, the bee keepers are anxious that other good honey-producing plants be introduced to increase still more the amount of floral honey. As before stated, bees show a marked preference for floral nectar over honeydew. There is on the islands a great deal of land which is not only not cultivated at present, but which, from its rough character, can never be cultivated. There is doubtless an opportunity for the introduction of some honey plants to the mountainous regions, where they would not interfere with cultivated crops or grow on land of value for any other purpose.

From the sad experiences in plant introductions on the islands, it will be well to watch any new honey-plant introductions very carefully. Lantana, which is used so much as a greenhouse plant on the mainland, was introduced a few years ago. It soon escaped from the greenhouse, however, and found in the climate of the islands the proper conditions for rank rapid growth. It spread to all the islands and forms dense jungles 10 feet or more in height, through which it is impossible to pass without cutting a path (Pl. VIII, fig. 2). Various methods are being tried with a view to exterminating this pest, but to-day there is still plenty of lantana. The cost of clearing a lantana thicket for cultivation is about $10 an acre. Lantana secretes nectar, but that is the only good thing which can be said for it. It was, of course, not introduced for its honey, but this experience should make the bee keepers cautious about what plants they bring in. The sages of California are now being tried, as well as various kinds of mangroves.

WAX PRODUCTION.

The price of honey fluctuates relatively much more than that of beeswax. On account of the fact that Hawaiian honey has been selling for a low price and also because of the peculiar character of most of the honey, the bee keepers of the islands are desirous of converting their honey into wax, if it can be done, even at no great profit. The long shipment necessary to get their honey to market means more or less loss by leakage and heavy freight. Wax does not lose anything

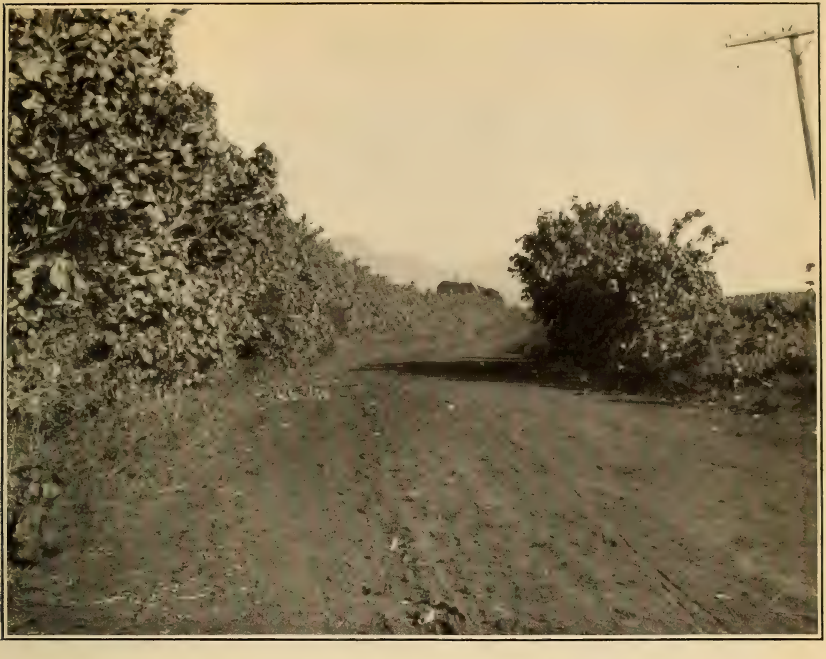

FIG. 1.—HAU HEDGE. (ORIGINAL.)

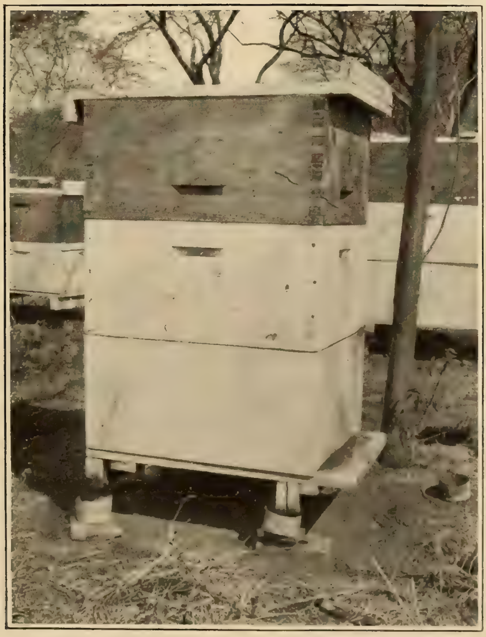

FIG. 2.—A HIVE SET UP IN CANS TO KEEP OUT ANTS. (ORIGINAL.)

in transit, and naturally also wax weighs much less than an amount of honey of equal money value, and the freight would be very much reduced.

When the author arrived on the islands one of the first questions asked him was how to bring about a production of more wax and less or even practically no honey. After getting the available data, which were freely given, a method was suggested which promises to give some results, if we may judge by results obtained in some experiments conducted in the short time which could be spent in Hawaii. Before outlining this proposed method it will be well to review the basis for the recommendations.

It is a well-known fact among bee keepers that at the time a swarm is hived the activity of the inmates of the new home is at its height. The bees not only collect nectar with great vigor, but, there being no wax in the hive under natural conditions, the wax secreters become very active and in a marvelously short time the hive is supplied with combs. It is also true, of course, that wax is secreted at any time during the active season when it is necessary that more combs be built to accommodate brood or stores, provided, of course, that there is room. If a comb is removed from the center of the brood chamber or from the super, it is replaced as needed, but, as a rule, not so rapidly. The rapidity of the honey flow influences this wax secretion greatly.

The amount of honey consumed in the secretion of a pound of wax is a much-debated question among students of bees, the various estimates ranging all the way from 2 to 20 pounds. There seems to be little hope at present of arriving at anything definite on this question, and the author is strongly inclined to the belief that the reason for this great variation in estimates is due to the fact that the same amount of honey is not always needed to bring about a desired result. It would be bootless, therefore, to pay any attention to this phase of the question in trying to get a method of wax production. Sylviac, in a series of articles in L'Apiculteur for 1901, offers evidence that the amount of honey consumed in secreting a pound of wax is least following swarming, and this quite coincides with the fact that wax building is most rapid at that time.

In dealing with wax secretion on a commercial basis, data must be drawn from the receipts per colony under different methods of management. The actual consumption of honey becomes of minor importance. It was learned that the average annual return per colony, after deducting freight charges, leakage, and other expenses incurred after the honey leaves the apiary, would not exceed $2.50. The hives are on an average two stories high during the entire year and, during the height of the honey flow, are often higher. All figuring was done on a basis of two-story colonies. The wax in such a hive weighs over 6 pounds,[a] averaging in value $1.80, Hawaiian wax being of the finest quality.

As additional data, it was learned that it is possible to increase the number of colonies very rapidly. In one remarkable case reported, 20 colonies were increased to 420 in eight months. This fact shows that a colony of bees can build up very rapidly under the conditions existing on the islands. It must also be remembered that in cane sections there is practically no stopping of the honey flow.

In view of all these facts it was obvious that if the wax be taken from each colony it will form a good beginning in the annual return from a colony. If, then, the colony is in as good shape in a year's time as it was when the wax was removed, there will be honey enough stored to make the annual money return higher than if the colony had been run for honey alone.

The method recommended is to shake the colony onto starters of foundation. The brood is placed over another colony to develop so that it may not be lost; the honey is to be extracted. By dividing the apiary into two parts, one-half may be shaken and the brood piled on the other half. These in turn may be shaken in three weeks or more and their brood added to the colonies shaken at first. This manipulation is identical with the shaking in treating for bee disease. Similar methods are often employed in honey producing to prevent swarming and to cause bees to work in the supers. In the present instance, however, there is an entirely different reason for the practice.

In the trial made with a view to wax production, a surprising showing was made, and it seemed obvious that the operation could be repeated in not more than three months' time, and probably less. If this be true, then there will be removed $1.80 worth of wax or more at each shaking, which means a considerable gain.

No positive statements of results can be made until the method has stood trial for a time. If this plan serves the purpose in Hawaii, it will also be valuable in other regions where there is a heavy honey flow for a long time.

DISEASE SURVEY.

The bee keepers of the islands were very anxious to learn whether or not they had any brood disease among their bees. They were quite certain that there was none, but desired this opinion to be confirmed. For this reason the apiaries visited were carefully examined by the author and absolutely no trace of any known infectious disease was found. In view of the fact that a brood disease would spread rapidly in that climate, the bee men may consider themselves extremely fortunate.

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[a] Since this was written the writer has received a report, dated May 19, 1908, on this series of experiments, showing that 8.88 pounds were extracted from 20 frames, this being the actual average in an apiary of 120 colonies.

Some time ago Mr. D. L. Van Dine sent to the Bureau of Entomology a sample of brood which had died, and it was reported that there had been considerable loss on this account. There was no indication of any infectious disease in the sample, and before another sample could be obtained the trouble had disappeared. Of this trouble Mr. Van Dine wrote, under date of April 27, 1906:

> About the 1st of January it began and appeared simultaneously in several of the apiaries of the ——— Honey Company. In the majority of cases [of hives having this trouble] from one-half to three-fourths of the brood died when the larvæ were nearly full grown or after transforming to the pupæ. The sunken caps and black color resembled the descriptions of foul brood, but there was no odor or other symptoms. Many of the pupæ showed signs of life after turning nearly black and some adults emerged before dying * * *. As a precaution the bees were fed medicated sirup, but I am of the opinion that the trouble is not an infectious disease, but due to improper food. When the algarroba, our principal honey tree, had ceased to flower the main source of pollen was gone, but the bees could still get an abundance of honey from the sugar cane. The bee bread was scanty, very dark in color, and rather hard. I have not been able to trace out where they got it. Probably from various weeds * * *. The algarroba is coming in flower again and it is a fact that the trouble is fast disappearing, and I am inclined to believe that it was due to the food conditions I mentioned * * *.
>
> On the island of Kauai the same trouble appeared at the same time as on this island and the conditions are exactly the same. On the island of Molokai the trouble did not occur and there they have no sugar cane and when the honey plants failed the queens ceased to lay and no outbreak of the disease occurred.

Under date of June 5, 1906, he wrote:

> For a time after the bees began to bring in pollen in abundance the trouble seemed to disappear, but just now in certain colonies it is as serious as ever. This seems to contradict the idea that the trouble is due to food conditions.

While the author was on the islands only one case was seen which resembled what was described in 1906. This was in an apiary on the island of Kauai. The dead larvæ in no way resembled those which die of American foul brood or European foul brood. There is no indication that the trouble is contagious, and the dead larvæ resembled certain phases of what is generally called "pickle brood."

The bee keepers are anxious that no disease be allowed to enter their territory, and at the request of the Hawaiian Bee Keepers' Association the author drew up a letter of recommendation which is here given:

> For the information of your association in formulating proposed regulations relative to the establishment of an effective quarantine against the various diseases of the bee, I take pleasure in presenting the following statements as my opinion concerning the questions involved.

1. *The nature of the diseases.*—There are now recognized two diseases, virulent and contagious in their character, which attack the brood of the bee. These are known as American foul brood and European foul brood. It is definitely known that American foul brood is caused by a bacterium, *Bacillus larvæ*, and from the symptoms and behavior of European foul brood it is almost certain that the latter disease is likewise caused by a micro-organism. There are other diseases recognized by bee keepers, but it is not known that they are infectious.

2. *Methods of spread.*—It is known that both diseases mentioned (European foul brood and American foul brood) are transmitted in the following manners:

(*a*) By bees from healthy colonies robbing the hives of diseased colonies.

(*b*) By the bee keeper feeding honey from diseased colonies, as in the case of feeding for winter stores in the colder parts of the mainland.

(*c*) By the accidental feeding of honey from diseased colonies, which has been extracted and sold in bottles or other containers. (This applies to partly empty honey bottles or cans which may be thrown out carelessly where bees can gain access to them.)

(*d*) By the introduction of queens taken from apiaries in which disease is present and which are shipped in cages stocked with candy made from infected honey.

It will be obvious from the local conditions that (*b*) does not apply to the Hawaiian Islands. It is doubtless true also that (*a*) does not apply. I can not say positively that neither disease is present in the Territory, but it is almost certain that they are not.

Means of preventing the introduction of disease to the Hawaiian Islands.—As an immediate action, it is desirable that all queens which are shipped to the Territory be removed from the cages in which they arrive and be introduced to colonies from a clean cage containing candy made from honey free from disease organisms. This precaution, which is a very simple operation, will be a very good assurance that disease will not be brought to your islands with imported queens.

It is desirable that as soon as possible a quarantine apiary be established, to which all imported queens shall be introduced. After two months' time, if the colonies to which the queens are introduced are free from disease, the queens may be sent to the owner with perfect safety.

It is above all desirable that no honey of any kind shall be shipped to your islands unless it comes from healthy colonies and is accompanied by a certificate of a qualified inspector of apiaries that such is the case. This precaution is of much more importance than those against infection through importation of queens. The bee keeper who imports queens would probably soon recognize disease if it appeared in a colony containing a choice imported queen, but if disease is brought in with honey it might gain a strong foothold before its discovery. This provision will not constitute a prohibition of the importation of honey, since on the mainland there are now about 55 qualified apiarian inspectors.

On September 2, 1908, the Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii passed regulations pertaining to the importation and inspection of honey bees and honey, which placed restrictions on such importations for the purpose of preventing the introduction of contagious diseases.

U. S. D. A., B. E. Bul. 75, Part VI. A., January 25, 1909.

MISCELLANEOUS PAPERS ON APICULTURE.

THE STATUS OF APICULTURE IN THE UNITED STATES.

By E. F. Phillips, Ph. D.,
In Charge of Apiculture.

INTRODUCTION.

Few persons realize the magnitude, importance, and possibilities of the present bee-keeping industry in the United States. Those who are conversant with the pursuit, and even those who are extensively engaged in it, generally fail to comprehend what an important factor in the agriculture of the country apiculture is as a whole, or how much the honey bee, by collecting nectar and storing it to produce a commercial product, is instrumental in saving our resources. Although the total value of bee products is small as compared with the value of the products of many other branches of agriculture, it nevertheless has an importance which should not be overlooked. The object of this paper is to review the present status of the industry with a view to pointing out where we may look for advancement.

Few rural pursuits have made greater progress during the past half century than has this one. Before that time the bees of this country were kept in box hives, and as a result the annual average crop of honey per colony was small. In addition to this handicap in not being able to manipulate the bees as was needed, bee keepers generally lacked a knowledge of the methods of caring for them. With the invention of movable-frame hives by Langstroth in 1851 it became possible to care for bees properly and to manipulate in such a way as to get the best crop. As the use of this type of hive and of the honey extractor became general, bee keepers have become better educated in modern methods of manipulation, and the industry has advanced from a negligible quantity to its present important place in agriculture.

In the vast majority of cases bee keeping is not the principal occupation, but is carried on in conjunction with some other business.

According to the census of 1900 the average number of colonies on farms reporting them was 5.8106, valued at $14.40—a very small investment. In some recent work of this Bureau[a] it has been found that in the State of Massachusetts the average number of colonies reported was 5.5 per bee keeper. This last figure should not be taken as an index to the condition in the whole country, for as one goes farther west the holdings are found to be larger. In California, for example, while there are some small apiaries, the majority are quite large, and the average is several times that of Massachusetts. The number taken from the census can scarcely be accepted as correct.

The number of men who rely solely on the production of honey and wax for a livelihood is rather small, and most of the extensive producers of the West carry on some other business, at least for the part of the year when the bees are less active. The reason for this is found in the nature of the industry. Any location is limited as to the number of colonies of bees which it will support, and in consequence a bee keeper must either carry on some other business or establish numerous outapiaries to enable him to keep bees enough to make it an occupation which will support him. Since the establishment of outapiaries is attended with certain disadvantages, it usually follows that bee keeping becomes a minor part of a man's occupation or even a side line.

Then, too, bee keeping is taken up by many as a recreation or a subject of nature study. Such persons do not wish to make it their sole or main occupation. Many farmers also keep a few colonies of bees and add to their income to some extent in that way. It is obvious that bee keeping must continue to be an avocation in the majority of cases.

This brings up for consideration a question which has been much discussed by those interested in bringing about an advance in the industry: Shall an attempt be made to increase the number of bee keepers, or to make better ones of a smaller number? Bee keepers who follow the pursuit on a commercial scale are usually anxious that there be no increase in the number engaged in the business, but rather a decrease, with an accompanying advance in the proficiency of those so engaged. This desire is not wholly selfish, for unless the increase is directly in the territory of the individual his crop is not affected.

It frequently happens that a local market is ruined, temporarily at least, by some uninformed bee keeper who keeps a few colonies and sells a poor grade of honey for a ridiculously low price, thus making it almost impossible for the up-to-date bee keeper to sell his honey for what it is worth in the same community. This condition of affairs would not occur were it not for the fact that, for table use at least, honey does not rank as a necessity, and the usual causes for changes in market price do not operate so completely as is the case with other commodities.

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[a] Gates, Burton N.—Bee Keeping in Massachusetts. Bulletin No. 75, Part VII, Bureau of Entomology, U. S. Dept. of Agriculture. (In preparation.)

The main objection to numerous small bee keepers, rather than fewer and more expert ones deeply engaged in the industry, is, that when the larger number is interested it can not be hoped that all will become proficient. Under normal circumstances this matters little, since anyone has a right to neglect his bees if he so desires, but when some contagious disease is present in a region this becomes a serious matter. The expert bee keeper can not hope to rid his bees of disease if there are a great many unqualified bee keepers in his neighborhood. Under such a circumstance—which unfortunately is becoming quite general in this country—the negligent bee keeper keeps property which, if diseased, constitutes a nuisance, and is a constant menace to the progressive man, for it is impossible to tell when neglected colonies may become infected.

If progress is to be made toward getting the largest possible honey crop from the United States, it will hardly be done by making bee keepers who own an average of 5 colonies. It must be done by progressive bee keepers financially interested to an extent sufficient to compel them to combat disease and to do their utmost to get the entire crop. We may not hope to attain this ultimate condition, but an effort might be made to discourage negligent and indifferent bee keeping.

In spite of the fact that bee keeping is the sole occupation of but few, it nevertheless commands attention in that it adds considerably to the resources of the country and increases the income of thousands of people. The possibilities for its increase are great, and the advancement of this vocation is a worthy object as aiming to save for human use a resource which is now so generally wasted.

SCOPE OF THE INDUSTRY.

It is very difficult to estimate accurately the annual value of the products of the apiary, but from various sources of information it is reasonable to suppose that the value of the honey produced annually in the United States is on the average about $20,000,000 and of wax about $2,000,000. Since the honey harvest depends so completely on various climatic conditions affecting the secretion of nectar, it is obvious that there is an enormous variation in the annual yield.

As nearly as can be learned, the number of sections for comb honey manufactured annually by supply dealers is between 60,000,000 and

75,000,000, and that may be considered as a fair estimate of the average number of pounds of comb honey produced in the United States, since relatively few sections are exported. Extracted honey is produced more extensively, and it is safe to say that the annual crop is three or four times that of comb honey. Taking into consideration also the chunk honey sold and the honey not marketed but used in home consumption, the estimate of $20,000,000 is none too high.

It may be of interest to compare the data of various years given by the census. Table I gives the amount of honey and wax, with the ratio between them. It is very interesting to note a reported increase in the ratio of honey to wax produced as the use of the honey extractor has become more general.

Table I.—*Production of honey and wax in the United States, 1840–1900.*

Census of—	Honey.	Wax.	Ratio of honey to wax.
	Pounds.	*Pounds.*	
1840		628,303	
1850	[a] 14,853,790		
1860	23,366,357	1,322,787	17.7:1
1870	14,702,815	631,129	23.3:1
1880	25,743,308	1,105,689	23.3:1
1890	63,897,327	1,166,588	54.8:1
1900	61,196,160	1,765,315	34.7:1

[a] Beeswax and honey.

The last census, that of 1900, recording crop data for 1899, gives the following:

Total number of farms reported in census		5,739,657
Number of farms reporting bees		707,261
Percentage of total		12.3
Number of colonies, June 1, 1900		4,109,626
Average number per farm reporting bees		5.8106
Value of bees		$10,186,513
Pounds of honey in 1899		61,196,160
Pounds of wax in 1899		1,765,315
Value of honey and wax in 1899		$6,664,904
Number of farms of white farmers reporting bees		677,985
Percentage of all farms of white farmers		13.6
Number of farms of colored farmers reporting bees		29,276
Percentage of all farms of colored farmers		3.8
Average crop per farm reporting bees:		
Honey	pounds	86.5
Wax	do	2.5
Average value of honey and wax per farm reporting bees		$9.42
Average value of bees per farm reporting		$14.40
Average value of bees per colony		$2.48
Average pounds of honey per colony		14.9
Average pounds of wax per colony		.43
Average value of honey and wax per colony		$1.62

Tables II and III[a] give additional data on distribution.

TABLE II.—*Number and value of swarms*[1] *of bees, June 1, 1900, on farms and ranges, by geographic divisions.*

Geographic division.	Number of farms.	Farms reporting bees.	Per cent of farms reporting bees.	Swarms of bees.	Value of bees.
The United States	5,739,657	707,261	12.3	4,109,626	$10,186,513
North Atlantic	677,506	64,110	9.5	413.709	1,370,732
South Atlantic	962,225	151,863	15.8	854.909	1,664,636
North Central	2,196,567	233,721	10.6	1,187,856	3,505.675
South Central	1,658,166	225,100	13.6	1,289,384	2,513,397
Western	242,908	32,421	13.3	362,381	1,123,647
Alaska and Hawaii	2,285	46	2.0	1,387	8,426

[1] The word "swarms" used in census reports evidently should be "colonies."

TABLE III.—*Pounds and value of honey and wax produced on farms and ranges in 1899, with averages per farm reporting, by geographic divisions.*

Geographic division.	Honey.		Wax.		Value of honey and wax.	
	Total.	Average per farm.	Total.	Average per farm.	Total.	Average per farm.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*		
The United States	61,196,160	86.5	1,765,315	2.5	$6,664,904	$9.42
North Atlantic	6,855,027	106.9	182,819	2.9	801,147	12.50
South Atlantic	9,468,843	62.4	379,192	2.5	1,029,233	6.78
North Central	20,055,502	85.8	396,604	1.7	2,353,001	10.07
South Central	14,849,824	66.0	588,960	2.6	1,553,141	6.90
Western	9,870,094	304.4	216,020	6.7	920,089	28.38
Alaska and Hawaii	96,870	2,105.9	1,720	37.4	8,293	180.28

Taking the number of farms keeping bees as the basis, the five most important bee-keeping States, June 1, 1900, were Texas, with 60,043 farms reporting; Kentucky, with 44,974; Missouri, with 41,145; North Carolina, with 41,051; and Tennessee, with 38,225.

Taking the number of swarms, or colonies, of bees as the basis, the five leading States were Texas, with 392,644; North Carolina, 244,539; Tennessee, 225,788; Alabama, 205,369; and Missouri, 205,110. Of the States included in the series given first, Texas, Missouri, Tennessee, and North Carolina are found in the second.

Taking the value of the bees as the basis of classification, the five leading States were Texas, with $749,483; New York, $593,784; Pennsylvania, $531,578; Kentucky, $527,098; and Missouri, $508,217.

The five greatest producers of honey in 1899 were Texas, with 4,780,204 pounds; California, 3,667,738; New York, 3,422,497; Missouri, 3,018,929; and Illinois, 2,961,080. California, which has not been included in any of the preceding classifications, here stands second.

Of the States producing wax, Alabama led with 162,020 pounds; Texas was second, with 159,690; North Carolina third, with 135,920; California fourth, with 115,330; and New York fifth, with 84,075.[b]

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[a] Twelfth Census of the United States, 1900, Vol. V, Agriculture, Part I, p. ccxxxiii.

[b] Twelfth Census of the United States, 1900, Vol. V, Agriculture, Part I, pp. ccxxxiii–ccxxxiv.

It will be noticed that the data on honey and wax crops do not at all agree with the author's estimate given above. In the light of the evidence previously given, it is obvious that the census figures are entirely too small and are far from doing justice to the industry. The other data are probably much more reliable. It is hardly a fair test to compare 1900 data as to the number of bee keepers with those of 1906, but it should be noted that in the recent work of the Bureau in Massachusetts [a] there were reported 2,127 bee keepers as compared with 1,799, the number given in the census.

IMPORTS AND EXPORTS.

Tables IV to VII show the imports and exports of honey and wax through the ports of entry of the United States. The data for these tables were obtained through the courtesy of the Bureau of Statistics of this Department.[b]

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[a] Gates, Burton N.—Bee Keeping in Massachusetts. Bulletin No. 75, Part VII, Bureau of Entomology, U. S. Dept. of Agriculture. (In preparation.)

[b] Tariff schedules on honey and wax under the different acts of Congress subsequent to 1841 are as follows:

Acts of—	Tariff on honey.	Tariff on wax.
August 30, 1842	Not specifically mentioned	15 per cent ad valorem.
July 30, 1846	30 per cent ad valorem	20 per cent ad valorem.
March 3, 1857	24 per cent ad valorem	15 per cent ad valorem.
March 2, 1861	Not specifically mentioned	10 per cent ad valorem.
July 14, 1862	15 cents per gallon.	20 per cent ad valorem.
June 30, 1864	20 cents per gallon	Not specifically mentioned.
March 3, 1883	20 cents per gallon	20 per cent ad valorem.
October 1, 1890	20 cents per gallon	Free.
August 27, 1894	10 cents per gallon	Free.
July 24, 1897	20 cents per gallon	Free.

Table IV.—*Imports of honey into the United States, 1901–1908, by countries from which consigned.*

Year ending June 30—	Cuba.				Mexico.			
	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.
1901	809,784	$31,591	3.9	37.0	727,728	$25,659	3.5	33.3
1902	131,736	5,807	4.4	6.6	1,361,052	33,269	2.4	67.8
1903	1,565,088	64,867	4.1	45.3	1,166,796	31,697	2.7	33.8
1904	1,296,912	42,597	3.3	52.4	652,404	12,345	1.9	26.3
1905	1,575,768	57,918	3.7	66.1	516,804	10,477	2.0	21.7
1906	756,312	26,239	3.5	45.6	724,488	18,107	2.5	43.7
1907	915,744	33,380	3.6	43.4	884,340	27,534	3.1	42.0
1908	1,162,872	46,726	4.0	45.7	1,045,944	37,926	3.6	41.1

Year ending June 30—	Santo Domingo.				Haiti.			
	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.
1901	327,876	$13,091	4.0	15.0	146,256	$5,086	3.5	6.7
1902	160,440	4,853	3.0	8.0	35,184	1,173	3.3	1.7
1903	198,204	4,897	2.5	5.8	255,588	5,013	2.0	7.4
1904	373,212	8,982	2.4	15.1	58,476	1,273	2.2	2.4
1905	162,792	4,063	2.5	6.8	44,052	779	1.8	1.9
1906	27,840	820	2.9	1.7	81,444	1,703	2.1	4.9
1907	31,272	746	2.4	1.5	188,640	4,849	2.6	8.9
1908	49,068	1,376	2.8	1.9	106,116	2,870	2.7	4.2

Year ending June 30—	All other countries.				Total.		
	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.[a]	Value.[b]	Average price per pound in cents.
1901	174,708	$8,172	4.7	8.0	2,186,352	$83,599	3.8
1902	319,200	11,281	3.5	15.9	2,007,612	56,383	2.8
1903	266,676	8,926	3.3	7.7	3,452,352	115,400	3.3
1904	94,500	3,856	4.1	3.8	2,475,504	69,053	2.8
1905	83,988	3,482	4.1	3.5	2,383,404	76,719	3.2
1906	68,568	3,782	5.5	4.1	1,658,652	50,651	3.1
1907	88,068	4,345	4.9	4.2	2,108,064	70,854	3.4
1908	179,904	9,527	5.3	7.1	2,543,904	98,425	3.9

[a] Custom-house returns of honey are given in gallons, assumed here to weigh 12 pounds.
[b] Imports of honey into the United States are subject to a specific duty.

Values.—The values of all imported articles, whether subject to ad valorem or specific duties or free of duty, are regulated by the act of Congress of June 10, 1890.

The actual market value or wholesale price of such merchandise as bought and sold in usual wholesale quantities at the time of exportation to the United States in the principal markets of the country from whence imported, and in the condition in which such merchandise is there bought for exportation to the United States or consigned to the United States for sale, including the value of all cartons, cases, crates, boxes, sacks, and coverings of any kind, and all other costs, charges, and expenses incident to placing the merchandise in condition ready for shipment to the United States.

Valuation deceptions.—The value of imported articles subject to ad valorem duties is believed to be determined with more accuracy, according to the legal method of valuation, than other imports, with specific duties or free, and exported articles; the valuation of dutiable imports and of exports dutiable in foreign countries tend to understatement, and the valuations of imports that are free of duty are often inflated for the purpose of trade deception.

TABLE V.—*Imports of beeswax into the United States, 1901–1908, by countries from which consigned.*

Year ending June 30—	Cuba.				Mexico.			
	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.
1901	110,778	$28,539	25.8	51.8	13,446	$3,080	22.9	6.3
1902	157,839	44,364	28.1	38.6	23,366	5,070	21.7	5.7
1903	147,917	42,357	28.6	30.3	162,332	36,476	22.5	33.2
1904	98,455	28,682	29.1	23.1	167,843	45,673	27.2	39.5
1905	79,926	24,006	30.0	21.4	87,943	23,265	26.5	23.5
1906	158,523	48,120	30.4	27.0	46,421	13,485	29.0	7.9
1907	331,942	93,702	28.2	36.2	47,262	15,417	32.6	5.2
1908	264,984	76,431	28.8	39.5	41,489	13,290	32.0	6.2

Year ending June 30—	Santo Domingo.				Haiti.			
	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.
1901	41,225	$10,241	24.8	19.3	11,286	$4,292	38.0	5.3
1902	73,364	21,118	28.8	17.9	6,373	3,013	47.3	1.6
1903	82,829	21,364	25.8	16.9	25,276	7,692	30.4	5.2
1904	80,783	21,061	26.1	19.0	38,106	10,359	27.2	9.0
1905	46,816	11,193	23.9	12.5	62,547	16,047	25.7	16.8
1906	34,052	8,596	25.2	5.8	27,311	7,326	26.8	4.6
1907	67,264	16,941	25.2	7.3	48,831	13,555	27.8	5.3
1908	55,311	13,085	23.7	8.2	58,147	15,379	26.4	8.6

Year ending June 30—	All other countries.				Total.		
	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.	Value.[a]	Average price per pound in cents.
1901	37,038	$9,732	26.3	17.3	213,773	$55,884	26.1
1902	147,764	42,372	28.7	36.2	408,706	115,937	28.4
1903	70,222	19,331	27.5	14.4	488,576	127,220	26.0
1904	39,981	11,103	27.8	9.4	425,168	116,878	27.5
1905	96,337	26,610	27.6	25.8	373,569	101,121	27.1
1906	321,310	90,487	28.2	54.7	587,617	168,014	28.6
1907	421,789	125,022	29.6	46.0	917,088	264,637	28.9
1908	251,595	76,584	30.4	37.5	671,526	194,769	29.0

[a] Imports of beeswax into the United States are free of duty.

Values.—The values of all imported articles, whether subject to ad valorem or specific duties or free of duty, are defined by the act of Congress of June 10, 1890, as—

The actual market value or wholesale price of such merchandise as bought and sold in usual wholesale quantities at the time of exportation to the United States in the principal markets of the country from whence imported, and in the condition in which such merchandise is there bought for exportation to the United States or consigned to the United States for sale, including the value of all cartons, cases, crates, boxes, sacks, and coverings of any kind, and all other costs, charges, and expenses incident to placing the merchandise in condition ready for shipment to the United States.

Valuation deceptions.—The value of imported articles subject to ad valorem duties is believed to be determined with more accuracy, according to the legal method of valuation, than the value of imports with specific duties or free of duty, or the value of exported articles; the valuations of dutiable imports and of exports dutiable in foreign countries tend to understatement, and the valuations of imports that are free of duty are liable to inflation for the purpose of trade deception.

TABLE VI.—*Imports and exports of honey of the United States, 1855–1908.*

[The terms "Comb" and "Extracted" honey used in these headings are used in place of "Unstrained" and "Strained" honey in the reports of the Department of Commerce and Labor.]

Year ending June 30—	Imports.			Exports.[a]		
	Pounds.	Value.	Average price, in cents.	Comb.	Extracted.	Both comb and extracted.
1855	5,245,908	$138,189	2.63			
1856	5,142,432	169,643	3.30			
1857	4,975,908	202,436	4.08			
1858	4,790,388	149,915	3.13			
1859	5,448,372	196,751	3.61			
1860	4,626,420	163,027	3.52			
	30,229,328	1,019,961	3.37			
1861	3,970,320	146,464	3.69			
1862	4,311,960	195,485	4.53			
1863	3,394,896	158,852	4.68			
1864	3,461,832	162,071	4.68			
1865	1,899,072	87,954	4.63			
1866	3,332,724	135,253	4.06			
1867	2,614,824	128,537	4.91			
1868	2,546,112	117,172	4.60			
1869		77,405		$1,152		
1870		76,459		8,520		
		1,285,652				
1871		56,891		2,479		
1872		80,014		2,677	$28,168	$30,845
1873		128,925				
1874		88,379		714	57,895	58,609
1875		109,368		3,586	29,563	33,149
1876		72,935		2,534	26,079	28,613
1877		61,205		36,302	54,663	90,965
1878	1,403,724	67,111	4.78	6,212	24,638	30,850
1879	1,005,984	48,169	4.79	134,728	27,958	162,686
1880	1,293,360	59,806	4.63	26,820	28,439	55,259
		772,803				
1881	2,364,528	110,059	4.65	109,007	89,761	198,768
1882	1,831,164	78,976	4.31	19,082	30,592	49,674
1883	1,939,500	78,911	4.07	27,826	4,907	32,733
1884	1,530,432	57,443	3.75			68,764
1885	1,821,432	67,572	3.71			224,212
1886	1,520,688	45,551	2.99			44,735
1887	1,766,592	47,679	2.69			67,154
1888	1,893,816	46,210	2.44			7,579
1889	968,976	26,624	2.74			93,888
1890	757,428	27,191	3.59			113,101
	16,394,556	586,216	3.58			900,608
1891	572,880	20,808	3.63			83,325
1892	841,236	31,418	3.73			78,048
1893	2,113,764	79,396	3.76			15,115
1894	1,831,716	56,156	3.07			127,282
1895	809,328	22,993	2.84			118,873
1896	959,820	30,609	3.19			90,969
1897	797,184	27,599	3.46			22,368
1898	1,159,248	38,158	3.29			98,504
1899	1,514,604	51,599	3.41			55,900
1900	1,762,320	70,857	4.02			30,191
	12,362,100	379,593	3.07			720,575
1901	2,186,352	83,599	3.82			55,574
1902	2,007,612	56,383	2.81			106,112
1903	3,452,352	115,400	3.34			64,220
1904	2,475,504	69,053	2.79			69,317
1905	2,383,404	76,719	3.22			63,367
1906	1,658,652	50,651	3.05			111,945
1907	2,108,064	70,854	3.36			93,690
1908	2,543,904	98,425	3.9			78,102

[a] Only values are given in reports.

TABLE VII.—*Imports and exports of beeswax into the United States, 1851–1908.*

Year ending June 30—	Imports.			Exports.		
	Pounds.	Value.	Average price, in cents.	Pounds.	Value.	Average price, in cents.
1851				[b] 415,923	[b] $122,835	[b] 29.5
1852				[b] 326,368	[b] 91,499	[b] 28.0
1853				[b] 376,693	[b] 113,602	[b] 30.2
1854				[b] 327,554	[b] 87,140	[b] 26.6
1855				[b] 257,415	[b] 69,905	[b] 27.2
1856				[b] 270,320	[b] 74,005	[b] 27.4
1857				[b] 315,378	[b] 91,983	[b] 29.2
1858				[b] 366,246	[b] 85,926	[b] 23.5
1859				[b] 290,374	[b] 94,850	[b] 32.7
1860				[b] 362,474	[b] 131,803	[b] 36.4
				[b] 3,308,745	[b] 963,548	29.1
1861				[b] 270,425	[b] 94,495	[b] 34.9
1862				[b] 142,312	[b] 47,383	[b] 33.3
1863				[b] 258,901	[b] 80,899	[b] 31.2
1864	[a] 54,087	[a] $13,667	[a] 25.3	[b] 341,458	[b] 170,418	[b] 49.9
1865	20,899	6,414	30.7	[b] 338,776	[b] 261,381	[b] 77.2
1866	[a] 23,900	[a] 10,420	[a] 43.6	[b] 272,987	[b] 130,650	[b] 47.9
1867	25,617	5,450	21.3	[b] 253,065	[b] 96,282	[b] 38.0
1868		5,609		[b] 826,887	[b] 255,365	[b] 30.9
1869					189,396	
1870		[a] 19,897		[b] 346,668	[b] 137,443	[b] 39.6
					[b] 1,463,712	
1871		[a] 16,817		[b] 365,195	[b] 113,070	[b] 31.0
1872		[a] 20,196		[b] 446,474	[b] 126,130	[b] 28.3
1873		14,661		[b] 374,486	[b] 118,053	[b] 31.5
1874		7,918		[b] 342,068	[b] 113,800	[b] 33.3
1875		15,400		[b] 353,425	[b] 96,578	[b] 27.3
1876		14,668		[b] 218,610	[b] 69,127	[b] 31.6
1877		[a] 16,844		[b] 276,891	[b] 84,461	[b] 30.5
1878		13,302		[b] 326,613	[b] 95,074	[b] 29.1
1879		[a] 15,861		168,745	45,823	27.2
1880		[a] 2,766		193,217	48,880	25.3
		[a] 138,433		3,065,724	910,996	29.7
1881		[a] 6,733		164,090	40,203	24.5
1882		[a] 5,312		124,227	32,325	26.0
1883	168,879	41,681	24.7	59,455	17,604	29.6
1884	48,123	9,323	19.4	51,748	16,042	31.0
1885	91,754	21,211	23.1	30,877	9,758	31.6
1886	26,546	5,718	21.5	136,179	36,626	26.9
1887	10,843	2,371	21.9	90,350	24,997	27.7
1888	51,702	9,411	18.2	78,070	20,554	26.3
1889	75,951	11,773	15.5	99,917	23,918	23.9
1890	126,319	20,282	16.1	171,391	19,727	11.5
		133,815		1,006,304	241,754	24.0
1891	379,135	80,485	21.2	120,548	30,027	24.9
1892	271,068	65,487	24.2	127,470	31,898	25.0
1893	248,000	62,024	25.0	77,434	22,048	28.5
1894	318,660	80,024	25.1	469,763	118,093	25.1
1895	288,001	78,776	27.4	309,212	90,875	29.4
1896	273,464	75,970	27.8	222,612	65,844	29.6
1897	174,017	43,339	24.9	195,048	56,462	28.9
1898	272,097	72,473	26.6	151,094	41,827	27.7
1899	452,016	109,957	24.3	152,494	41,916	27.5
1900	213,813	51,526	24.1	319,379	91,913	28.8
	2,890,271	720,061	24.9	2,145,054	590,903	27.5
1901	213,773	55,884	26.1	140,276	39,464	28.1
1902	408,706	115,937	28.4	125,283	36,541	29.2
1903	488,576	127,220	26.0	70,811	21,337	30.0
1904	425,168	116,878	27.5	55,631	16,545	30.0
1905	373,569	101,121	27.1	85,406	24,966	29.2
1906	587,617	168,014	28.6	101,726	29,894	29.4
1907	917,088	264,637	28.9	117,169	36,392	31.0
1908	671,526	194,769	29.0			

[a] Including manufactured wax.
[b] Stated simply as "wax," and including wax of all kinds, as well as beeswax.

The following figures give additional evidence of the magnitude of the industry:

Bee keepers' associations (estimated)	100
Number listed in office of Bureau[a]	86
Journals devoted to bee keeping[b]	3
Breeders of queens actually recorded (not including duplicates)	[c] 164
Breeders of Italians	146
Breeders of Carniolans	37
Breeders of Caucasians	35
Breeders of Cyprians	6
Breeders of "Holylands"	5
Breeders of Banats	6

In addition there are several large factories devoted either entirely or in large part to the manufacture of supplies for use in the apiary.

VALUE OF THE HONEY BEE AS A POLLENIZING AGENT.

The honey bee is of great value as a pollenizing agent, and in estimating the value of the industry in adding to the resources of the country this phase of the subject must be included. Other insects, of course, aid in this way, but the honey bee occupies a peculiar position in a consideration of this subject.

Waite[d] mentions a large number of species of insects which visit pear blossoms, but says: "The common honey bee is the most regular and important abundant visitor, and probably does more good than any other species." Müller,[e] in his very comprehensive study of the fertilization of flowers, summarizes his results as shown in Table VIII.

TABLE VIII.—*Fertilization of plants by insects.*[f]

	In Low Germany.			On the Alps generally.			Above the limit of trees.		
	Species of insects.	Visits observed.	Per cent of total.	Species of insects.	Visits observed.	Per cent of total.	Species of insects.	Visits observed.	Per cent of total.
Coleoptera	129	469	8.96	83	337	5.90	33	134	4.82
Diptera	253	1,598	30.55	348	1,856	32.49	210	930	33.46
Hymenoptera	368	2,750	52.57	183	1,382	24.20	88	519	18.68
(Apidæ)	(205)	(2,191)	41.31	(120)	(1,141)	20.00	(49)	(402)	14.46
Lepidoptera	79	365	6.98	220	2,122	37.15	148	1,190	42.83
Other insects	14	49	.94	7	15	.26	3	6	.21
Total	843	6,231	....	841	5,712	....	482	2,779	....

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[a] Several of the State and county organizations are affiliated with the National Bee Keeper's Association.

[b] Gleanings in Bee Culture, Medina, Ohio, founded 1873. Bee-Keeper's Review, Flint, Mich., founded 1888. American Bee Journal, Chicago, Ill., founded 1861.

[c] The total number is probably twice this.

[d] Waite, M. B., 1895.—The Pollination of Pear Flowers. Bulletin No. 5, Division of Vegetable Pathology, U. S. Dept. of Agriculture.

[e] Müller, H., 1883.—The Fertilization of Flowers. Trans. by Thompson, London

[f] From Müller, pp. 596–597.

In Table VIII the entire family of the Apidæ is credited with 41.31 per cent of the visits, but in the text Müller frequently refers to the fact that on some plants the honey bee far outnumbers all other insects. He speaks of the honey bees and the bumblebees of the genus Bombus as playing "by far the most important part in fertilizing our [German] indigenous flowers." On the other hand, Britton and Viereck[a] attempt to show that the honey bee is not so important as has generally been claimed by horticulturists and entomologists. They find that "honey bees were exceedingly scarce in comparison with other species of Hymenoptera—or in fact with other insects." From collections made from flowers in 1904 at the experiment station at New Haven and in 1905 at Branford, Conn., the following records were made:

	Gooseberry.	Red currant.	Black currant.	Wild plum.	Japan plum.	Sweet cherry.	Peach.	Apple.	Pear.	Quince.	Blackberry.	Raspberry.	Strawberry.
Hymenoptera	46	28	15	5	23	29	8	32	17	22	8	13	4
Apis mellifera	......	......	......	......	......	1	1	1	......	1	1	......	......
Diptera	19	27	7	8	16	4	......	16	9	7	......	......	......
Coleoptera	4	2	1	2	5	4	......	3	3	1	......	......	2
Hemiptera	3	2	......	......	......	......	......	1	......	......	......	......	......
Total number of specimens	72	59	23	15	44	37	8	52	29	30	8	13	6

> It seems fair to assume that on account of their great numbers the small bees belonging to the Halictidæ and the Andrenidæ are more important agents in carrying pollen than has been supposed, and in the vicinity of New Haven during the seasons of 1904 and 1905 were of far greater benefit in pollinating the flowers of the plants from which they were collected than were the honey bees.

Earlier in the paper they say: "It is not known to the writers that bees are kept in the immediate vicinity of the experiment station; there are several hives less than 2 miles away. Wild honey bees are probably not very abundant so near the city."

There are several facts which should be taken into consideration in connection with this paper—facts not mentioned by the authors. In the first place, comparatively few honey bees are kept in the part of Connecticut around New Haven. Furthermore, a scourge of bee disease is said to have decimated the bees of Connecticut some years ago, and doubtless this decreased the number of bees in a wild state as much as it is known to have done in the case of bees in hives. No disease is now recorded from the vicinity of New Haven, but it may still be there unreported, it being found in many parts of the State. Further, in the vicinity of cities, bees are generally less prevalent than in the country. The principal point which should be considered, however, is that the winter of 1903–4, just before these counts were made, was exceedingly severe, and 75 per cent of the colonies of honey bees in New England are reported to have died. Honey bees do not hibernate, and long-protracted cold weather is detrimental to them. Taking these facts into consideration, it is not so strange that the honey bee played a minor part in pollinating the flowers in the cases investigated.

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[a] Britton and Viereck, 1906.—Insects Collected from the Flowers of Fruit Trees and Plants. Fifth Report of the Connecticut State Entomologist for the Year 1905, New Haven, Conn.

While in the particular cases observed by these authors the honey bee was of little value as a pollenizer, the ease with which an enormous number of honey bees could be brought to the aid of the orchardist places this species in a class by itself. Estimating the population of a colony of bees as low as 10,000 in early spring, it may easily be seen how readily the orchardist may insure pollination by carrying a few colonies of bees to the orchard, provided of course that the weather is such that bees can fly while the trees are in bloom. Under adverse conditions in winter the other insects may be so decimated that they are few in number, but while honey bees may also be killed off in winter, there are means of protecting them, which is not the case with the purely wild species.

Fruit growers as a rule recognize the value of the honey bee to their industry. Taking into consideration the insurance of pollination by transporting colonies of bees to the places where their services are needed, it is safe to say that the indirect benefit of the bee-keeping industry annually adds to the resources of the country considerably more than the amount received from the sale of honey and wax.

PRESENT SOURCES OF LOSS.

There are several sources of great loss to bee keepers which might be eliminated to a large extent by careful manipulation, but there is much work which must be done before bee keepers are able to overcome all these difficulties. Certain losses are expected regularly, and, while some do their utmost to overcome them, an annual loss must figure in their calculations.

Swarming.—The average bee keeper loses many of the swarms which issue from his hives, and these escaping swarms may well be valued at a high figure. By careful manipulation and the use of large hives swarming may be largely controlled, but among the majority of bee keepers too little attention is given to this phase of the work and nothing is done until the swarm actually issues. In the production of comb honey smaller hives are generally used, and the control of swarming becomes more difficult. It is doubtless true that swarms aggregating in value $1,000,000 are lost every year. This loss may be considerably reduced.

The greatest obstacle in the control of swarming is the fact that the activities bringing on swarming are so little understood. This phenomenon represents the bee's natural method of increasing the number of colonies, and it may be attributed to instinct. This, however, does not explain what factors induce the bees to swarm or what their activities are previous to swarming. When the behavior of the bees before and during swarming is better understood, we may have greater hope of a method of control.

Winter losses.—The losses in winter are considerable, due largely to starvation, dampness, too long a time without a cleansing flight, or extreme cold weather. By wintering bees in cellars in the North this loss may be considerably reduced, but while much has been written on this subject the general loss to northern bee keepers is probably at least 10 per cent every winter. An even temperature of about 45° F. and a dry atmosphere are considered best, and the best method of obtaining these conditions is an individual problem.

Where bee keepers do not pay any attention to the selection of their best stock for breeding purposes, the loss of 10 per cent or more of their colonies in winter must not be looked on as a total loss, for generally the poorest colonies succumb. In the southwestern part of the United States the winter problem can be said not to exist in the way it does in the North, and, as a result, a large part of the bees kept there are of poor stock, vastly inferior in many cases to equally neglected stock in portions of the country where winters are severe.

On the other hand, in these warmer portions of the country it is necessary to leave much heavier stores of honey in the hives to carry the colonies over from one season of activity to the next, so that "wintering" is very expensive. It has been suggested seriously that colonies be placed in cold storage for several months to save this heavy consumption.

"Winter loss" is in many cases caused by disease, which so weakens the colony during the summer that it is not able to survive the winter. In such cases the bee keeper is usually ignorant of disease.

Waste of wax.—No other manipulation of the apiary is so primitive as wax extraction and nowhere is there more room for improvement. As every bee keeper knows, it is difficult to remove wax from the comb, particularly in the case of old combs which have been used for brood rearing for years. The amount of wax wasted every year by inadequate methods of extraction amounts to thousands of dollars annually. In most cases over 10 per cent of the wax remains in the "slumgum," and even by careful work 5 per cent is left. By repeated rendering, the amount may be reduced, but the time necessary for this usually makes it unprofitable.

With the advent of the movable-frame hive and honey extractor it became orthodox to continue the use of combs year after year. The invention of methods making this possible was of such great benefit to the apicultural industry that it may almost be said that without it there would be no industry. At the same time it may be that bee keepers have formed the habit of using their combs in this way, and in consequence are losing wax. It must not be overlooked that it is part of the life activity of bees to build wax, and in working bees to get the maximum financial return from them it may be desirable to allow them to spend some energy on wax production. For example, immediately after swarming, under natural conditions, bees secrete a large amount of wax; they also, of course, build wax at other times, but there is much more of a tendency then than at any other period of their activity. There is good reason to believe, also, that at the time specified the amount of honey consumed in building a pound of wax is less than at any other time. With wax worth so much more per pound than honey, it would seem to be desirable in some cases to take advantage of the wax-building ability of bees.

In rendering wax from comb the usual procedure is to squeeze the combs in a press while hot. With but few exceptions, this is the only method used. Since this takes too long, and especially since all the wax can not possibly be removed, it would be wise to look for some other method. A better method would not only mean greater profits, but would be a gigantic step in advance in bee-disease eradication.

The loss due to inadequate extraction does not, of course, include the enormous loss from wax which is thrown away or which is allowed to be destroyed by wax moths for lack of fumigation.

Enemies.—When it is considered that bees live in a large community and seemingly present an excellent opportunity for the intrusion of parasitic forms and predaceous animals, it is a matter of surprise that they are so free from this source of loss.

The wax moths (*Galleria mellonella* L. and *Achroia grisella* Fab.) rarely trouble thrifty colonies, and therefore are not dreaded by progressive bee keepers in the colonies; they do, however, often destroy stored combs.

Diseases.—From the standpoint of present need there is no question in apiculture which at all compares in importance with the control of bee diseases. There are now recognized two distinct brood diseases which are contagious and which annually cause enormous losses to those engaged in the industry. There is reason, too, to believe that these diseases are spreading to new localities at a rapid rate, and unless vigorous steps are taken there can be no doubt that in a few years they will be distributed to every part of the United States.

The apathy of bee keepers, as a class, to these scourges is remarkable, in view of the fact that information is available which should point out the dangers now incurred by inadequate efforts toward the control of these pests, or in most cases by no effort at all.

As an example of the annual loss from this source, the following figures, furnished the author by Mr. Charles Stewart, one of the State inspectors, from the statistics of the New York department of agriculture, are of value. These figures are based on the actual number of colonies suffering from European foul brood which were destroyed or ordered destroyed by the inspectors of apiaries and do not represent the decreased returns from colonies not treated or from those affected with disease and treated. This epidemic started about 1897. The decrease in annual loss will be discussed later.

Previous to 1899	$39, 383
During 1899	25, 420
1900	20, 289
1901	10, 853
1902	5, 860
During 1903	$4, 741
1904	2, 220
1905	1, 725
Total	110, 491

In the majority of cases it is absolutely impossible to estimate the losses, because so little is known of the actual territory covered; but if a loss of $25,000 is possible in a few counties in one State and there are many areas much larger where disease is equally epidemic, the loss may well be estimated at $2,000,000 annually.

The figures of the epidemic in New York offer an excellent example of what may be done in eradicating a contagious disease. Unfortunately that State had no means for taking up an extermination of European foul brood as soon as it appeared, but steps were taken to begin inspection as soon as such an innovation could be introduced. By hard work on the part of four competent inspectors the annual loss was rapidly reduced. The same results may be obtained anywhere by the employment of competent men to do the work, so that from a rapidly spreading epidemic, threatening the bee industry, the situation is changed until the disease becomes not so much a scourge as an inconvenience. In the case in question there can be no doubt that the annual loss would soon have reached $50,000 or that the industry would have been practically destroyed had no State aid been given just when it was.

Not only is inspection of value in a case of this kind, but it is of inestimable value in making possible the stopping of an epidemic in its early stages. To continue with New York as an example, the same disease, European foul brood, has since broken out in three other localities, but the force of inspectors went to work at once and there is little danger of serious trouble. It is safe to say that the value of inspection in this State is nearly equal to the annual value of the industry in the State. The value of the honey and wax produced in New York in 1899—the year State inspection was instituted—is given as $352,795 in the census for 1900. This is obviously too low.

Several States have passed laws for the control of these diseases and, in the majority of cases, the results are as good as can be expected. The laws are not always all that could be desired. Table IX shows the States having inspection and the force at work.

TABLE IX.—*Status of bee-disease inspection in the United States.*

State.	Method of inspection.	Number of inspectors.	Principal disease.	Authority.
California	County	15	American foul brood	State law.
Colorado	do	12	do	Do.
Idaho	Divisions of State.	2	do	Do.
Illinois	State	1	American foul brood and European foul brood.	State bee keepers' association. (No police power.)
Kansas	County	(?)	American foul brood	State law.
Michigan	State	1	American foul brood and European foul brood.	Do.
Minnesota	do	2(?)	American foul brood	Do.
Missouri	do	1	do	Do.
Nebraska	County	2	do	Do.
Nevada	do			(?)
New Mexico	do	1	American foul brood	Law against keeping diseased colonies.
New York	Divisions of State.	4	European foul brood and American foul brood.	State law.
Ohio	County	2	do	Do.
Oregon	do			(?)
Texas	Divisions of State.	4	American foul brood	State law.
Utah	County	4	do	Do.
Washington	do	1	do	Do.
Wisconsin	State	1	do	Do.

Other States are at work on this same question and it may be expected that within a few years the diseases will be controlled as much as is possible by inspection.

Badly proportioned distribution of apiaries.—A present source of loss to the industry as a whole is the fact that the available area for nectar gathering is not properly covered with apiaries; in some cases it is overstocked, but far more generally there is room for several times as many colonies. In pointing out the loss on this account it need scarcely be expected that a method for remedying the present conditions will immediately follow.

As apiculture advances, more and more of the available bee territory will be covered and, naturally, overstocking will be brought on in many cases. By natural growth of bee keeping the present lost nectar will probably be brought to the hives. Viewing the question, however, from the standpoint of the industry as a whole, it is desirable that this nectar be collected by bees under the management of intensive bee keepers—by men who can get the maximum crop from the bees. This can be brought about only by education of the men engaged in the work to the greatest possible proficiency. It can not be hoped that men owning but a few colonies will be sufficiently interested to carry on intensive apiculture. If, therefore, efforts are put forth to bring the industry to its highest point, they should be directed toward the making of specialists in larger numbers. Above all, there should be no "booming" of the industry, no effort to "popularize" it, for it is not desirable that everybody keep bees. Bee keeping requires careful work, and to get a financial profit is not possible in the majority of cases. To advocate bee keeping as a general avocation not only hurts reputable bee keepers but generally leads to grave disappointment on the part of those who are led into it by glowing accounts.

THE NEEDS AND POSSIBILITIES OF APICULTURE.

That there is room for growth in the bee-keeping industry admits of no doubt. The fact that honey for table use is a luxury rather than a necessity makes possible a great increase in marketing by the creation of a desire for it. This is recognized by those who are engaged in the building up of a local market for their product, for it is found that the amount of honey consumed in a community increases rapidly when honey is brought to its attention.

A large part of the honey put on the general market does not go into retail trade, but is used in manufacturing. This phase of the market is of relatively recent growth and, in spite of the fact that most bakers and confectioners pay a small price for honey, there is in this case also room for more. Several confectioners have stated to the author that they find it difficult to get enough honey in the general market for their own use.

In discussing the needs of the bee-keeping industry these may perhaps be best divided under three headings—scientific, economic, and educational. In naming them it does not follow that all are absolute necessities before the industry can reach its highest perfection, but there are many lines which should be taken up which, while not necessary, are very desirable in order that the men engaged in the industry may be well informed concerning the various phases of the science.

SCIENTIFIC NEEDS.

Statistical.—In order that honey and wax may come to hold a stable place in the market there should be available more detailed statistics as to the scope of the industry and, following that, properly timed crop reports, so that the products may sell for what they are worth.

Zoological.—In spite of all that has been written on races of bees, the subject is far from being completely exhausted. More reliable work should also be done on the anatomy and embryology of the bee.

Numerous papers and books have been written on these subjects, especially on anatomy, but they generally prove incorrect and unscientific when carefully studied. It is regrettable that too often pseudo-scientists have been allowed to impose on the bee-keeping public by sending out publications purporting to be the results of research which are in reality compilations in large part, and the actual observations of the author are not based on a proper preparation for such work. The amount of work done on the physiology of the bee is indeed meager; the problem is a difficult one, but as technique is perfected such work should be taken up. The whole basis of practical apiculture is a knowledge of the behavior of the bee; without such knowledge there could be no good practical work. Probably no insect has been studied from this standpoint more than has the honey-bee, but every new piece of work done simply points out new lines of work that are desirable.

Botanical.—Our knowledge of nectar-secreting plants now consists largely of random observations, usually for a limited locality, recorded in bee journals and books. Systematic work along this line, if done by competent observers, would give to the bee keeper the means of studying the possibilities of any locality as it can not now be done. More work is needed to give accurate information as to the part played by the honey bee in plant pollination, as well as data showing the present value of, and future possibilities in, that work.

Bacteriological.—The cause of one brood disease is now known,[a] but there is still a great deal of work to be done in the study of the bacteria of disease. This work is of the highest practical importance, for without a thorough knowledge of the organisms it is impossible to diagnose the more obscure samples, and only by a detailed study can information be gathered as to the amount of heat or disinfectant which must be used in combating disease.

Chemical.—Considerable work has been done on honey analysis, and a recent publication[b] of the Bureau of Chemistry of this Department is an excellent piece of work which lays the foundation of a good market for pure honey in making it possible to detect adulteration. In addition to what is already done, there should be a more detailed study of honeys from individual honey-plant sources.

ECONOMIC NEEDS.

There is or should be no sharp distinction between scientific and practical bee keeping. Practical bee keeping is but the application of discoveries made by scientific work. It is not always recognized, but it is nevertheless true, that careful systematic work on methods of wintering, production of the maximum crop of comb or extracted honey, or the like, is really scientific work on the behavior of the bee, and, if done properly, is just as truly scientific work as any that has been mentioned previously. Breeding of better bees and inspection for disease or for honey adulteration are but practical applications of scientific investigations.

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[a] White, Dr. G. F.—The Cause of American Foul Brood. Circular No. 94, Bureau of Entomology, U. S. Dept. of Agriculture, 4 pp., 1907.

[b] Browne, C. A., and Young, W. J.—Chemical Analysis and Composition of American Honeys, including a Microscopical Study of Honey Pollen. Bulletin No. 110, Bureau of Chemistry, U. S. Dept. of Agriculture, 93 pp., VI plates, 1908.

The question of breeding is economic and very important. It is doubtless a fact that at least three-fourths of the colonies of bees now found in the United States are not what they should be or what they would be if proper attention were paid to breeding. By requeening such colonies from good stock the annual output of honey would be enormously increased, provided, of course, that the improved stock were properly manipulated.

> At present the tendency among bee keepers is to accomplish by manipulation the things which would be attempted in breeding. Thus, instead of breeding for nonswarming bees, we have attempts at the construction of hives which provide environments conducive to nonswarming. Instead of breeding for prolificness we have trials at using two queens in one hive to get the same result. Good wintering qualities are replaced by extra care in wintering, and tongue length becomes less important by the use of alsike clover for pasturage in place of red clover, the nectar of which is largely lost to the honey bee. Activity in honey gathering is replaced by the keeping of a large number of colonies.
>
> As long as the bee-keeping field is not more completely filled, these methods of avoiding the breeding problem will be more or less successful. The time should come, however, and probably will, when bee keepers can no longer neglect this line of work.[a]

EDUCATIONAL NEEDS.

While the problems above enumerated represent a vast amount of work which must be done, the problem which entails the greatest amount of labor is the spread of information to the individual bee keepers who want it. Several agencies are now at work doing valuable service, among which may be mentioned the journals devoted to bee keeping, associations of bee keepers, the teaching of apiculture in some agricultural colleges, and the work of some experiment stations. The Bureau of Entomology aims to aid in the work. Most of the text-books on bee keeping are educational rather than records of personal investigation, for in large part they very properly draw from many sources and prepare the data for the use of the bee keepers.

First of all there must be an improvement in the methods of compiling the work done by others. The literature on bee keeping is so enormous that the average individual can not attempt to cover it, and to aid in this phase of the work this Bureau is arranging a bibliography of apicultural papers and books. This has been begun only recently, but it now contains about 8,000 titles and is growing rapidly. This bibliography is in conjunction with the files containing the results of investigations carried on in the Bureau, as well as synopses, translations, and notes on the work of others in various branches of the subject.

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[a] 1908. American Breeders' Association, Vol. IV, pp. 200–201.

The greatest difficulty encountered is the finding of the way to get in touch with the bee keepers to present to them the results of work. Naturally the bee journals are anxious to do the same thing to increase their subscription lists, and the associations to increase their membership. The Bureau of Entomology has recently tried, as an experiment, direct communication with all the bee keepers in Massachusetts and the results are highly satisfactory; so much so, in fact, that the same work is being carried on in two other States. The amount of time and work that is necessary, however, makes it impossible to carry out this work generally.

Under this heading comes also the education of the public to the use of honey. In most cases this must be done by the bee keeper in his own locality. The average amount of honey consumed per individual is now too small, and can be increased by some proper means of bringing it to the attention of the public.

When the situation is carefully studied, it becomes evident that the possible annual crop of honey and wax is several times greater than the present crop. If bee diseases can be properly controlled and good information be properly disseminated, there is good reason for considering the future of commercial apiculture as very hopeful. The industry of apiculture depends on commercial bee keepers and not on the bee keeper with small interests.

SUMMARY.

The growth of apiculture during the past half century has been remarkable and its present extent is little understood.

Bee keeping is usually not the sole occupation, but is a side line.

There are in the United States over 700,000 bee keepers producing annually $20,000,000 worth of honey and $2,000,000 worth of beeswax.

The average number of colonies per bee keeper is less than 6.

The annual importation of honey amounts to about 2,500,000 pounds, and that of wax to about 700,000 pounds.

The honey bee probably does more good to American agriculture as a pollenizing agent than as a honey producer.

The present sources of loss are due to swarming, winter losses, waste of wax, enemies, disease, and wasted nectar. Of these sources of loss, contagious diseases are the greatest and demand attention.

There is much need of further investigations in apiculture, and a few of the desirable lines of work are pointed out. The work to be done is grouped in three classes—scientific, economic, and educational.

Bee keeping as an industry is benefited only by the making of expert bee keepers financially interested in the business. The persons interested but little are a serious detriment to the industry, especially in regions where bee diseases exist.

U. S. D. A., B. E. Bul. 75, Part VII. Issued May 24, 1909.

MISCELLANEOUS PAPERS ON APICULTURE.

BEE KEEPING IN MASSACHUSETTS.

By Burton N. Gates,
Expert in Apiculture.

HISTORICAL SKETCH.

When, in 1620, the Pilgrims landed at Plymouth, this country knew no bees; the Indians in their languages had no equivalents for bee, honey, or wax. In Elliot's remarkable translation of the Bible he was obliged to use the English word for honey, with sometimes an Indian termination. Scarcely, however, had churches been erected, scarcely were clearings made in the wilderness for growing agricultural necessities, when the settlers turned their attention to securing honey bees from England. That such remarkably early trans-Atlantic shipments of bees were successful there can be no doubt. Josselyn, who visited New England twice, once in 1638 and again in 1663, speaks of "the honey-bee, which are carried over by the English and thrive there exceedingly,"[a] but he does not tell when the first attempts to secure bees were made. Belknap,[b] however, wrote "that the first person who brought a hive of bees to this country [New England] was rewarded with a grant of land; but the person's name, or the place where the land lay, to whom the grant was made, I have not been able to learn." Unfortunately the records of the Colonies were not available to Belknap.

Newbury, a coast town north of Boston, was established in 1635. There the first effort to promote bee keeping in the New World was made. Furthermore, the importance of the industry was of municipal moment to the extent of holding out to one John Eales, who was then living in what is now Hingham, Mass., an inducement to come to Newbury for the purpose of teaching the settlers how to make hives and to care for bees. In August, 1644, Eales came "to one John Davis a Renter of a farm with ye expectation of his doing service which the Towne was not acquainted with."[a] Apparently, however, John Eales was not, financially or otherwise, a success. He was later arrested and put in jail in Ipswich, according to the record, and, on May 14, 1645, "It is conceived John Eales should be placed in some convenient place where he may be implied in his trade of bee-hive making, etc.; & ye town of Newbury to make up what his work wanteth of defraying ye charge of his livelyhoode."[b]

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[a] Josselyn, John. 1675. An Account of Two Voyages to New England, p. 120. Second edition. London. "The second edition is the first, with a new title page merely."—Sabin. Reprinted in Massachusetts Historical Society Collections, Vol. III, third series, p. 292, and by William Veazie, Boston, 1865.

[b] Belknap, Jeremy. 1792. A Discourse Intended to Commemorate the Discovery of America * * * to which are added, four dissertations * * * 3. On the Question, Whether the Honey-bee is a Native of America? * * * Boston, Belknap & Hall. 132 pages.

There can be little doubt that John Eales is the man to whom Belknap refers and to whom credit is due as the earliest bee keeper in the colonies.[c]

Further convincing evidence of the very early introduction of bees into New England is the date of their importation which Haydn[d] gives. According to this author, "bees were introduced into Boston, New England, in 1670, and have since spread over the continent." The source of his information is not given, but it is probably in some of the port records and can not refer to the first importation.

From these early times until more than a century later little or nothing is known of bee keeping in the State. In fact, during this epoch apiculture in the Old World was not well developed. It was not until the middle of the eighteenth century that writings on bees began to appear in Europe in any considerable number. Bees were receiving some attention in Massachusetts at this time, as is shown by a letter of a father to his son, dated, "Sutton [Massachusetts] June the 2d, 1788."[a] Besides speaking of sending to his son some homespun clothes the father adds, "as for news we have no grate to rite to you our bees have swormed yesterday and they flew of today."

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[a] Massachusetts Archives, Vol. L, pp. 4–5. [Manuscripts in the State House, Boston.]

[b] 1853. Records of the Governor and Company of the Massachusetts Bay in New England. Boston. Vol. 2, p. 101. [Period covered, 1642–1649.] John Eales was "Freeman made att the Generall Court, May 14, 1634." Ibid., Vol. 1, p. 369.

[c] See also: Adams, George W. 1906. Massachusetts Bee Keeping in 1644. American Bee Keeper, Vol. XVI, pp. 280–281.

Gerstäcker, A. 1862. Über die geographische Verbreitung und die Abänderungen der Honigbiene nebst Bemerkungen über die Ausländischen Honigbienen der alten Welt. (Zur XI. Wanderversammlung Deutsche Bienenwirthe zu Potsdam am 17, 18, und 19 September, 1862.) Potsdam. According to Von Buttel-Reepen this paper was given as "a card of admission" to those attending the Potsdam meeting. It has apparently become lost, excepting one copy from which Von Buttel-Reepen reprinted it as a part of his paper, "Apistica."

Von Buttel-Reepen, Dr. H. 1906. Apistica. Beiträge zur Systematik, Biologie, sowie zur geschichtlichen und geographischen Verbreitung der Honigbiene (*Apis mellifica* L.), ihrer Varietäten und der übrigen Apis-arten. Mittheilungen aus dem Zoologischen Museum zu Berlin, III, Heft 2, 8 fig., pp. IV+121–201. Issued also as a separate.

[d] Haydn, Joseph. 1904. Haydn's Dictionary of Dates and Universal Information. 23d edition. New York. Also other editions.

New England is reputed to have suffered severely from attacks of bee moths in the early part of the nineteenth century. There appears to have been a period of general devastation by this enemy from about 1800 to 1850. It handicapped the industry considerably, and, according to some, completely wiped it out in certain localities. Writing from Greenfield in 1853, L. L. Langstroth says:[b] "The present condition of practical bee keeping in this country [meaning the whole of New England and New York] is known to be deplorably low. From the great mass of agriculturalists * * * it receives not the slightest attention." There is room for considerable doubt, however, whether the moth was the primary cause of this devastation, as is explained below under the headings, "Enemies" and "Disease."

At the middle of the nineteenth century Langstroth, who had been experimenting for several years, brought out his invention, the movable-frame hive. As is explained under the head of "Hives," this revolutionized the industry; at that time modern bee keeping began.

Considering the very early date of the first introduction of bees to what is now Massachusetts, and that from this locality as a center much of the present-day bee keeping[c] spread westward with the home seekers, it is not a little surprising to discover so few extensive bee keepers in Massachusetts, while there are many in New York and Vermont. Compensating, however, for the lack of extensive bee keepers, there is a vast number of small apiaries; their number in proportion to the territory is probably greater than in any other State in the Union. There are at least 2,100[d] who derive some profit from their bees. Were these 2,100 to keep twenty-five colonies each and were their apiaries properly distributed over the State, there might not be forage enough to support them; but such is far from reality. The average is only five and a half colonies per bee keeper, which is evidently too small. In this is a key to the bee-keeping situation of the State; if the resources are to be fully utilized, more bees must be kept, not by more bee keepers, for there are too many small ones at present, but by several hundred proficient and energetic bee men properly distributed.

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[a] A photograph of this letter is in the possession of the writer.

[b] Langstroth, L. L. 1853. Langstroth on the Hive and the Honey-Bee, a Bee-Keeper's Manual. Northampton. First edition.

[c] The details of the present status of bee keeping in this paper are based upon the returns from a series of questions sent to every known bee keeper in Massachusetts. The method of securing the statistics was described in the author's paper read before the Association of Economic Entomologists, Baltimore, Md., December 29, 1908. This paper is published in the Journal of Economic Entomology, Vol. II, No. 2, pp. 117–120, April, 1909.

[d] By actual count, the recorded bee keepers for Massachusetts number 2,127. This exceeds the number recorded in the 1900 census by 328, which, considering that the author's work was accomplished through mail while the federal census is the result of a house-to-house canvass, suggests a deficiency in the figures of the federal census reports. Of the 2,127, 1,050 reported.

EXPERIENCE OF BEE KEEPERS IN MASSACHUSETTS.

Although there are too few bees kept, it is interesting to ascertain how experienced the Massachusetts bee keepers now are. In order to gain this information, a question, "How long have you kept bees?" was included in the list of questions circulated throughout the State. By thus knowing the length of time these men have been keeping bees, some idea of their proficiency may be reached. Of those who reported to the author, 38 per cent have had less than five years' experience and must consequently be classed as amateurs. While this array of amateurs, at first glance, appears high, it becomes more significant upon considering that 32 per cent, having successfully passed their apprenticeship, report from five to fifteen years' experience, or, in other words, have persisted and succeeded in bee keeping. On the other hand, roughly estimating, 50 per cent of the bee keepers who undertake this branch of agriculture discontinue it within their first five years' trial. This is not due to lack of possibilities in the bee-keeping industry, but must be attributed in a large measure to sensational presentation, in the popular press and elsewhere, of the ease of managing and the huge profits to be derived from bees. This overstimulation of the bee industry is a positive detriment to the bee-keeping interests. The number of persons who have taken and will take time for a proper study of bee culture is exceedingly limited in proportion to the number who undertake the work uninstructed. Consequently a 50 per cent weeding-out process during the first five years of attempted bee culture is a stroke of fortune for the industry. After fifteen years' experience, and before the twenty-five-year mark of service is passed, there is another falling off. The figures of this census show that 16 per cent of those reporting have kept bees from fifteen to twenty-five years, which, when it is considered that a bee keeper is well along in life by that time and often must necessarily relieve himself of care and work, is exactly what might be expected. No less interesting is the fact that 16 per cent continue after twenty-five years of service. These are the truly old bee keepers, many of whom remember Langstroth and his experimenting. While they may not be exactly up-to-date, they are to be respected for their persistency.

For purposes of comparison divide the State into two sections, the eastern section to include Worcester County and all other eastern counties save Barnstable County, which is not at all comparable either in population or from an agricultural point of view. If these two sections be contrasted, there will be found an obvious difference in their population. In the eastern section the cities and towns are large and the population concentrated, while in the western part the population is less dense and is thus far less influenced, on the whole, by large communities than the eastern section. It is in the large communities that bee keeping is usually promoted by supply houses and conventions, and it is there also that the majority who seek rural recreation along lines promoted by popular agricultural papers reside. Consequently, it is to be expected that the progress and stimulation of bee keeping, either as a recreation or an industry, should first be felt in and adjacent to these communities. This is precisely what is noticeable in Massachusetts. Back in the country of the more strictly rural section of the State, where population acquires but slowly the progressive impulses which are first launched in the larger communities, there are fewer new or amateur bee keepers than in the more thickly populated eastern section. In this western section the ratio of beginners to advanced bee keepers is as 30 to 70; while in the eastern section, where are found two bee-keepers' societies, the proportion of beginners is larger, with a possible ratio of 41 to 59. Aside from the influence of societies in the eastern section, supply houses have had a noticeable effect in stimulating popular interest and in promoting new and improved methods. As is pointed out above, sensational stimulation is unfavorable to the industry.

TABLE I.—*Proportion of amateurs to practiced bee keepers in the eastern and western sections of Massachusetts.*

Section of State.	Amateur bee keepers (5 years and less).		Practiced bee keepers.				Total number of bee keepers reporting.
			5 to 15 years.	15 to 25 years.	25 years and over.	Per cent.	
	Number.	*Per cent.*	*Number.*	*Number.*	*Number.*		
West of Worcester County	95	30	105	56	67	70	323
Worcester County and east, exclusive of Barnstable County	302	41	209	104	94	59	709
Barnstable County	3	....	8	6	1	....	18
Total for the State	400	38	322	166	162	62	1,050

NUMBER OF COLONIES PER BEE KEEPER.

There are but two bee keepers in the State who report more than 100 colonies, but several have nearly this number.

TABLE II.—*Location of Massachusetts' largest apiaries, as reported for 1906.*

County.	50 to 75 colonies.	75 to 100 colonies.	100 colonies and over.	County.	50 to 75 colonies.	75 to 100 colonies.	100 colonies and over.
Barnstable		1		Middlesex	4	1	
Essex	1			Plymouth	1		[a]2
Franklin		1		Total	9	3	2
Hampden	2						
Hampshire	1						

[a] One of these bee keepers writes that he increased from 55 to 133 colonies in 1906.

It is a peculiar fact that in Worcester County, where more bees are to be found than in any other county and where bee keeping is progressive, none reports 50 colonies and few have even 25. The two largest bee keepers in the State are located in Plymouth County. That there are so few large bee keepers in Massachusetts is due, in the writer's estimation, to the heretofore unrecognized ravages of disease. This is discussed elsewhere in this paper and in another publication of this Bureau.[a] In Middlesex County, for instance, where, so far as at present known, disease is not prevalent, the greatest number of large bee keepers is found and also the second greatest number of colonies.

DISTRIBUTION OF BEES IN MASSACHUSETTS.

In the eastern section, exclusive of Barnstable County, with its high ratio of novices, there are practically as many colonies of bees per bee keeper as in the western section. According to the figures for 1906, the following table presents the conditions:

TABLE III.—*Distribution of bees in Massachusetts.*

Section of State.	Spring.		Fall—Number of colonies.
	Number of colonies.	Colonies per bee keeper.	
West of Worcester County	1,760	5.4	2,530
Worcester County and east, exclusive of Barnstable County	3,897	5.5	5,595
Barnstable County	182	10.0	227
Total for the State	5,839	5.5	8,352

From the foregoing table it will be seen that the minimum number of colonies is in direct disproportion to the large number of bee keepers. The large population might account for this in the east, but this does not explain why the western bee keepers have not enlarged their apiaries, which without question should ultimately result. Again, disease is beginning to exert its influence, and a more general understanding of its nature and remedies should benefit the industry.

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[a] Gates, Burton N. 1908. Bee Diseases in Massachusetts. Bulletin No. 75, Part III, Bureau of Entomology, U. S. Department of Agriculture. Washington. Bul. 124, Mass. Agr. Exp. Station.

INCREASE IN NUMBER OF COLONIES.

The figures on increase which the writer obtained show an increase from 5,839 colonies in the spring to 8,350 colonies in the fall of 1906, a gain of 2,413 colonies, or 42 per cent. This is below normal and suggests the prevalence of bee diseases.

PRODUCTION OF HONEY AND WAX.

The subject of first importance to every bee keeper is the crop—How much honey and wax do the bees produce? Unfortunately, however, the majority do not go beyond this and ask how much ought the yield to be?

HONEY CROP.

The honey production of the State is little more than one-tenth what it might be. The markets demand much more honey than is produced in the State. As nearly as can be ascertained, some 80 tons of honey are annually harvested. Most of this is not shipped, but is consumed by the producer or his neighbors. There is no evidence that any honey is shipped out of the State; on the contrary, much comb and extracted honey is annually imported from Vermont, New York, and sometimes from the far West and South.[a]

Approximately 100 tons represents the total consumption during 1906. This consumption varies greatly from year to year, depending on the crop, as, for instance, in 1907, when scarcely any honey was obtainable in the market. The man who shipped 5½ tons from Vermont the previous year sent less than 1,000 pounds in 1907. None was received from New York, as in the previous year. But the estimate for 1906 of 100 tons is only one-half the amount estimated as consumed in 1904.[b] That year 200 tons, divided among the inhabitants of the State, would have allowed less than two tablespoonfuls per capita as a year's ration. Since then, however, the population has increased to more than 3,000,000,[a] and with the estimated crop of 100 tons in 1906 would have afforded each person less than one tablespoonful. Too little honey is available in Massachusetts. This is borne out by the common experience of those who try to buy extracted honey in convenient amounts or even in bulk for table use. The writer's experience is that it is almost impossible to purchase at retail a 60-pound can of good honey or even of a poorer grade at any price. As for being able to buy a gallon or a quart, it is impossible unless the purchaser is willing to pay a high price for a lot of small, fancy bottles, which may or may not contain good-grade honey. With these facts in mind, it is evident that much may be done to improve the retail trade in extracted honey. Comb honey, on the other hand, is usually available either from a producer or a retail store.

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[a] In 1906, 5½ tons came to Worcester from Vermont; from New York State 2½ tons. In Boston the imports, according to this authority, were approximately the same. It may be roughly estimated, therefore, that for 1906 at least 10 or at most 20 tons were received from points outside of the State. This information was kindly furnished the writer by Hon. W. H. Blodget, in a letter dated Worcester, Mass., April 11, 1908.

[b] Gates, Burton N., and Dr. C. F. Hodge. 1904. Bee Keeping; How to meet its dangers and difficulties. Mass. Crop Rept., vol. 17, No. 6, pp. 30-40, Boston, October. Also Fifty-second Ann. Rept. of the Secretary of the Mass. St. Bd. of Agric., pp. 411-426, Boston, 1905.

The crop in Massachusetts for 1906, as reported by something less than half the number of bee keepers recorded, was 145,257 pounds, approximately 73 tons; but since only a little over half the recorded bee keepers were heard from, 80 tons would be a conservative estimate, as is shown below. It is somewhat surprising that this study should show the largest recorded crop, and especially so in view of the fact that the investigation was carried on through the mails, while census data are obtained by personal canvass. This at least suggests that the census figures probably do not justly represent the industry.

Although 145,257 pounds of honey, of which 108,660 pounds was comb and 36,597 was extracted, is the heaviest crop recorded for the State, the product looks pitifully small when it is remembered that single apiarists in the West frequently produce in a season a fourth to a third more honey than Massachusetts' annual crop. If the actually recorded crop is divided by the number of colonies reported in the spring of 1906, this is an average of but 24 pounds per colony. Conservatively estimating from experience and reports of large practical apiarists in New York State and the West, the average yield, considering all classes of bee keepers, should be about 35 pounds. This would have made Massachusetts' crop, merely from the recorded number of colonies, spring count, 204,330 pounds, or 102 tons. Consequently the estimate of 80 tons, assumed for convenience, is safe. The question is, however, a larger one. The possibilities of the forage and the number of colonies which it would support is more vital than criticism of the present discrepancy. The writer has already stated[a] that Massachusetts can support approximately 40,000 colonies of bees. This number, producing an average of 35 pounds of honey to the colony, would supply 1,400,000 pounds, or 700 tons, of honey a year, contrasted with 73 tons. This crop would not be especially burdensome, and, divided among the people, each would have less than a half pound a year. Furthermore, there is no immediate danger of the production of any such amount.

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[a] Mass. Census, 1905, population 3,003,680.

TABLE IV.—*Honey and wax production reported in Massachusetts.*

Date.	Honey.	Wax.	Sources of data.
	Pounds.	*Pounds.*	
1839	....	1,196	U. S. Census Rept. for 1840.
1849	....	[a]59,508	U. S. Census Rept. for 1850.
1855	73.677	2,324.5	3d Ann. Rept. Sec. Mass. Bd. Agric. for 1856.
1859	59,125	3,289	U. S. Census Rept. for 1860.
1865	80,356	2,454	13th Ann. Rept. Sec. Mass. Bd. Agric. for 1866.
1869	25,299	1,195	U. S. Census Rept. for 1870.
1879	49,397	2,463	U. S. Census Rept. for 1880.
1889	90,929	1,690	U. S. Census Rept. for 1890.
1899	109,050	6,250	U. S. Census Rept. for 1900.
1906	[b]145,257	1,289	The author's census.

[a] Includes both honey and wax product.
[b] Extracted, 36,597 pounds; comb, 108,660 pounds.

WAX CROP.

It is customary for bee keepers to save their old combs from year to year before rendering them, which produces an annual variation in the product. Futhermore, outbreaks of bee diseases cause much more comb to be rendered. Severe winters, which frequently result in a loss of bees, usually produce a relative increase in the wax output the following year. It is therefore difficult to calculate a representative annual product of wax. The commercial importance of the wax crop, and the relative returns from it as compared with honey, are gradually becoming more and more realized; therefore, as the honey product increases it is to be expected that the wax output will proportionally increase. Table IV presents all the recorded information on wax production in Massachusetts.

SOURCES OF HONEY.

Too little attention is given the nectar-yielding flora, even among those who seek a livelihood in the production of honey. Although it is sometimes difficult to learn the sources from which bees get their stores, a bee keeper should have some knowledge of the honey plants of his locality and their honey value.

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[a] U. S. D. A., Bur. Ent. Bul. 75, Pt. III, p. 23. Allowing an average of 100 to 125 acres to support a colony of bees, based on experience of large bee keepers who maintain a series of outyards, and eliminating 500 square miles as probably unavailable for bee pasturage, there remain 7,814 square miles, or 5,000,960 acres, for forage in Massachusetts, which would support approximately 40,000 to 50,000 colonies of bees.

White clover.—Among the several clovers, white clover ranks first. It is found in nearly all quarters of the State, but flourishes best on limed or limestone soils, and is particularly abundant in the northern and western parts of the State. Just over the line in the Champlain Valley of Vermont the chief source of honey is white clover, which grows there in tangles and mats. White clover honey ranks high in the market; its color and flavor make it one of the finest of American honeys.

Alsike clover.—This is frequently sown for forage, and is becoming more and more renowned as a honey source. Under favorable conditions it yields not only a good quality of nectar, but large quantities of it. It rivals the red clover, on which bees work to a limited extent, but in which the vast stores of nectar are too deep in the flower tubes to be within reach of the bee's tongue. Alsike blooms with white clover and will bloom a second time when white clover has ~~ceased,~~ thus prolonging the honey flow from clover.

Red clover.—This is also a more or less continuous bloomer, which, inasmuch as the second flowering brings smaller, shorter-tubed heads, is somewhat accessible to bees.

Sweet clover.—There are two species, white and yellow, but neither is abundant in Massachusetts. It is a bountiful source of honey elsewhere, and may become so in this State.

Crimson clover.—As a honey plant this is of slight importance as far north as Massachusetts.

Golden-rod and asters.—These plants, as reported in this State, rank close to the clovers in nectar secretions. Both begin to flower in July and continue until frost. The early bloom, however, is not visited by bees to any extent, and it is not until September that the flow begins, when the hive takes on a characteristic strong and pleasant odor. The honey, though rather dark and thick, has a rich, aromatic flavor, which many people consider superior. In Massachusetts a marketable surplus is frequently taken in September.

Fruit bloom.—Apple, pear, cherry, plum, peach, etc., which are found in abundance throughout the State, are next in importance. Fruit bloom is the source of early stores upon which the colonies build up for the clover harvest. Insufficient numbers of bees at this season and unfavorable weather make it difficult to secure a surplus from this source, but the fortunate bee keeper who does secure a crop should realize that he has a superior product. The body is heavy, the color is clear and light (usually an amber), and the flow comes with a rush which insures handsome sections; but best of all is the exquisite aroma of the apple blossom, which places fruit-bloom honey in a class by itself.

Linden or basswood.—Cutting for lumber has tremendously reduced the number of basswood trees in the State. It was once generally distributed in the forests, but at present occurs largely only in the northern and western woods. This is doubtless the most valuable tree honey plant in Massachusetts and, together with its value for timber, merits cultivation. It makes a fine shade tree. The honey has quite a characteristic flavor and aroma, but requires to be well ripened before its delicious qualities are appreciable.

Buckwheat.—This is a famous honey plant in New York State and is reported from all counties of Massachusetts. Here, however, it is far less extensively grown than across the line. Some bee keepers say they plant small fields for the sake of their bees, but there is great doubt if the bees benefit materially by it except in cases of extreme scarcity of nectar. The honey is dark, with a brownish or purplish cast, a heavy body, and a strong, rank flavor to those who are accustomed to more delicate honeys, such as clover or fruit bloom. Many in New York State, however, often prefer buckwheat to clover honey. Especially if extracted, it usually commands a good price.

Wild raspberry and blackberry.—In the highland pastures wild raspberry and blackberry abound. The nectar flow is of long duration, beginning soon after fruit bloom has ceased, and thus is an important stimulant for the clover harvest to follow. Cultivated varieties are quite as valuable for forage as the wild species.

Sumac.—There are several species of sumac which are important honey sources, but which are greatly underestimated by the majority of bee keepers. They are free bloomers and flourish in nearly all parts of the State. Apparently, however, the nectar yield is somewhat erratic. The writer recalls seasons in Worcester County when bees paid no attention to the great heads of greenish flowers. Sumac honey, although not light, has a clear and firm body with a pleasant flavor.

Locust.—Like the basswoods, locusts have been largely cut from the woodlands. There are several species now found to a limited extent by roadsides and in pasture walls, where they are valuable forage for bees. In Colrain, Franklin County, one bee keeper attempted to cultivate locust for his bees, but met with no great returns for his efforts. Another bee keeper reports that locust is sporadic, yielding nectar only once in three years.

Maple.—A considerable number of bee keepers report that maple is a honey plant. It is, to be sure, one of the best sources of pollen in early spring, which doubtless has confused the bee keepers and caused them to report it as a honey plant. Swamp maple is especially valuable in early brood rearing. Maple is probably of less importance as a honey source than, for instance, the mints, strawberry, and milkweed, which were reported but a few times.

Clethra.—This is also known as black alder and sweet pepper bush, and is a valuable honey-secreting plant, largely confined to a belt paralleling the eastern coast, where it thrives in profusion. The aroma, a sweet smell, powerful and penetrating, may be perceived a long distance from the bush. Bees work upon it freely, and unquestionably produce considerable surplus honey, which is of good body and light color.

These, so far as bee keepers' observations afford, are the most prominent honey plants. Of the remaining list—each reported from one to fifteen times—milkweed, wild cherry, knotweed, dandelion, strawberry, chestnut, mints, gill-over-the-ground, and mustard are of most importance. No one of these taken alone is a source of surplus honey in Massachusetts, but all are important in the total yield. The writer has observed, in the spring when fruit trees are in bloom, a perceptible effect of dandelion nectar upon the delicate flavor of fruit-bloom honey, producing the characteristic bitterish taste.

Milkweed.—Where milkweed occurs in large quantities it is a valuable honey plant. In Berkshire County, Mr. Dewey, of Great Barrington, reports that milkweed is an important source of nectar.

One bee keeper in Hampshire County reports the Tartarian honeysuckle as important and very productive. Sunflowers are valuable but must occur in considerable numbers to make a perceptible difference in the crop.

Most of these plants are quite as important, so far as the economy of the bee is concerned, for their pollen as for their nectar. For instance, the willow and skunk cabbage, while they are reported as honey plants, are far more important as pollen yielders, because at their season of bloom pollen is scarce. The chestnut and, to a certain extent, the dandelion are more valuable for the pollen which they yield than for the honey.

THE MORE IMPORTANT HONEY PLANTS IN MASSACHUSETTS.

TABLE V.—*List of the more important honey plants in Massachusetts.*

[Arranged according to frequency of report.]

Name.	Times reported.
Clovers:	
White (*Trifolium repens*)	626
Alsike (*T. hybridum*)	37
Red (*T. pratense*)	7
Crimson (*T. incarnatum*)	3
Sweet (*Melilotus alba* and *M. officinalis*)	3
Yellow (*T. agrarium*)	1
	677
Golden-rods (*Solidago* spp.)	330
Asters (*Aster* spp.)	99
	429

TABLE V.—*List of the more important honey plants in Massachusetts*—Cont'd.

Name.	Times reported.
Fruit bloom (includes pear (*Pyrus* spp.), apple, cherry, peach, plum (*Prunus* spp.), etc.	337
Linden or basswood (*Tilia* spp.)	160
Buckwheat (*Fagopyrum* spp.)	144
	641
Raspberry (*Rubus* spp.)	103
Blackberry (*Rubus* spp.)	23
	126
Sumac (*Rhus* pp.)	89
Locust[a] (*Robinia* spp.)	43
Maple (*Acer* spp.)	36
Clethra (*Clethra alnifolia*)	24

[a] Does not yield every year; "Once in three years," one bee keeper says.

LIST OF PLANTS REPORTED RELATIVELY FEW TIMES.

(Reported from one to fifteen times.)

Alder (*Alnus* spp.).
Arnica, white flowering (*Arnica montana*).
Barberry (*Berberis* spp.).
Blueberry (*Vaccinium* spp.).
Burdock (*Arctium lappa*).
Buttercups (*Ranunculus* spp.).
Button bush (*Cephalanthus occidentalis*).
Cherry, wild (*Prunus* spp.).
Chestnut (*Castanea dentata* (marsh)).
Columbine (*Aquilegia canadensis*).
Cowpeas (*Vigna catjang*).
Cranberry (*Vaccinium* spp.).
Cucumber, cultivated (*Cucumis* spp.).
Cucumber, wild (*Micrampelis lobata*).
Dandelion (*Taraxacum* spp.).
Elderberry (*Sambucus* spp.).
Elm (*Ulmus* spp.).
Gentian, fringed (*Gentiana crinita*).
Geranium, wild (*Geranium* spp.).
Gill-over-the-ground (*Glecoma hederacea*).
Gooseberry, wild and cultivated (*Ribes* spp.).
Hickory (*Hicoria* spp.).
Honeysuckle, Tartarian[a] (*Lonicera tatarica*).
Horse chestnut (*Æsculus* spp.).
Huckleberry (*Gaylussacia* spp.).
Knotweed (*Polygonum* spp.).
Milkweed (*Asclepias* spp.).
Mints, catnip, etc. (*Mentha* spp.).
Mustards, wild (*Brassica* spp.).
New Jersey tea (*Ceanothus americanus*).
Radish (*Raphanus* spp.).
Shad bush, wild (*Amelanchier botryapium*).
Skunk cabbage (*Spathyema fœtida*).
Strawberry, wild and cultivated (*Fragaria* spp.).
Sunflowers (*Helianthus* spp.).
Syringa (*Philadelphus* spp.).
Thyme[b] (*Thymus serpyllum*).
Viburnum (*Viburnum* spp.).
Willow (*Salix* spp.).
Witch-hazel (*Hamamelis virginiana*).

PERIODS OF NECTAR SECRETIONS IN DIFFERENT LOCALITIES.

Through the courtesy of several bee keepers the writer is able to present with considerable detail the periods of nectar secretion of the more important honey plants in several sections of the State. It should be remembered, however, that the dates of nectar yielding must necessarily vary from year to year and at different elevations in the same territory; consequently the data here presented may be slightly at variance with other observations.

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[a] Reported of importance and very productive in Hampshire County.

[b] Jackson, Joseph J. 1894. Through Glade and Mead. Jackson (p. 293) lists it for Worcester County. It was also reported to the writer three times from Berkshire County.

BERKSHIRE REGION.

(Furnished by E. H. Dewey, of Great Barrington, Mass.)

Pussy willow, April 1 to 15. Pussy willow in sheltered places will bloom as early as the 15th of March and be visited by bees for pollen. Whether they get honey as early as that from this source I do not know. Just when pussy willow begins to yield honey I can not positively state, for bees work on it very early, but I have seen them with tongues extended in search of honey as early as the dates indicated.
Soft maple, April 1 to 8.
Hard maple, April 20 to May 5.
Fruit bloom, May 1 to 25.
Raspberry, June 5 to 30.
Locust, June 5 to 15.
Wild mustard. Wild mustard, I am told, appears about six weeks after cultivation. It is most frequently seen here from the middle of June to the 1st of July.
Clover, June 5 to July 25.
White sweet clover, July 10 to August 25.
Sumac, July 10 to 20.
Basswood, July 1 to 15.
Milkweed, July 5 to 20.
Chestnut, July 10 to 15.
Buckwheat, August 1 to 25.
Smartweed, September 5 to frost.
Brook sunflower (*Bidens lævis*), September 5 to —. It is fairly covered with bees. I have seen three or four working on a single blossom. Grows on low land and margins of water.
Golden-rod, August 20 to frost. One variety of golden-rod appears here the middle of August, but never secretes honey.
Asters, September 1 to frost.
Tag alders, September 1 to frost. In my immediate locality tag alders are not common, but can be found in swampy places a few miles from here.

CENTRAL REGION.

(Furnished by Dr. James B. Paige, Massachusetts Agricultural College, Amherst, Mass.)

Fruit bloom, May 12 to 30. Cherry, plum, and peach are the earliest. Apple lasts the longest.
Clover, June 10 to August 1.
European linden, June 15 to July 1.
Raspberry, June 6 or 7 to about June 20.
American linden, July 21 or 25 and lasts ten days to two weeks.
Buckwheat, latter part of July or August 1. Lasts nearly a month, according to quality of soil and location.
Golden-rod and asters, September 1, lasting until frost.
Smartweed, August 25 until frost. Does not appear to secrete after frost comes.

Wild clematis, July 25 to September 1. Cultivated variety (*Clematis paniculata*) blooms early in September, but I doubt if it secretes honey; it is sparingly visited for pollen.

Thoroughwort, ceases about 1st of September.

About the 1st of April we get soft maple, willow, skunk cabbage, alder and some elms, and cultivated plants, such as crocuses, etc., which, I suspect, supply more pollen than nectar.

CAPE COD REGION.[a]

(Furnished by Mr. Allen Latham, Norwich, Conn.[b])

Dandelion, in May.

Huckleberry, in late May.

Blackberry,[c] in late May.

White clover, in June and July.

Common locust (in Truro), June.

Sumac (*Rhus copallina*) (occasionally), in July.

White alder (*Clethra alnifolia*), July to August.

Fireweed (*Erechtites hieracifolia*), August to September.

Cut-leafed water hoarhound (*Lycopus americanus*), August to September.

Burr-marigold, August to September.

Pink knotweed, August to September.

Various golden-rods, August to September, especially *Solidago sempervirens*, a gigantic variety of golden-rod which thrives in the sand along the beach.

Various asters, like those which are common all over New England, September to October.

Cranberry, flourishes and blooms for a long period. This may yield nectar.

Strawberry, grows wild by the acre and the children and women carry bushels upon bushels of these berries home every June. Possibly in that region this plant yields nectar.

The beach plum is an old settler and is found all about the Cape whitening all the beach and dunes with its blooms in May. Whether the bees get any honey from that bloom I do not know.

Wild cherry, both the black or "rum" and the "choke," grow in abundance. As these yield practically nothing inland, I judge they furnish the bees no nectar there.

Listed in the order of their importance to the bee keeper:

1. Huckleberry.—Without this one could not be sure of a crop of honey oftener than every other year, and possibly not one year in three.

2–3. Hoarhound and fireweed.—Probably the hoarhound should rank ahead of fireweed.

4. Fall flowers, golden-rod and asters especially.

The fall flowers will always furnish a crop if the weather permits the bees to gather it, but too often the weather is foggy or high winds blow, or else it is too cold. I have never had such crops of fall honey here (Norwich, Conn.) as I have had down among those sand dunes, once in three or four years, strong colonies laying upward of a hundred pounds.

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[a] A good account of bee keeping in this region is found in the following paper: Miller, Arthur C. 1906. A Unique System. How an Ingenious School Teacher Harvests Crops of Honey from a Desert. American Bee Keeper, Vol. XVI, pp. 206–210, October. Illustrated.

[b] Mr. Latham specifies that the data relate to the "plants known to yield honey near Provincetown," the extreme end of Cape Cod, about 50 miles direct by sea from Boston and 25 miles from Plymouth.

[c] It is possible that blackberry is very important. I do not know its honey, and the flavor may be lost in the honey from huckleberry bloom.

5–6. White clover and Clethra, about equal.
7. Sumac.

RACES OF BEES.

Among the bees of Massachusetts are found representatives of those kept in all parts of the United States. They occur only in relative degrees of purity, due to the fact that young queens often mismate. "Hybrid" means any cross between recognized races, but more particularly and generally the cross between Italians and Germans.

ITALIAN BEES.

According to the data at hand, 594 bee keepers say they have Italians. This does not mean pure Italians in every instance, but it does indicate that practically half of the bee keepers who reported have Italians, a highly encouraging condition. Furthermore, 342 report that they have hybrids, which may almost universally be interpreted as a cross between Italians and Germans. By adding this to the number who report Italians, it makes 936, or about 80 per cent, of those reporting who have some Italian in their hives. This clearly demonstrates the popularity of the race.

There are several strains of Italians, such as "long-tongued," or "red-clover," and "golden," or "five-banded," and the like. Although these strains are all found in Massachusetts, data concerning them is not sufficient to decide their relative merits or popularity.

GERMAN BEES.

Pure German or black bees are exceedingly scarce. In the county of Worcester the writer has seen what he believed to have been the pure-blooded Germans; but these colonies are seldom met with. Although, as is shown in the table below, 196 persons report that they have German bees, there is as much or even more doubt that these are strictly pure as there is doubt that all of the Italians reported are pure. This race, at least in Massachusetts, is destined to be supplanted by the Italians, although some bee keepers still complain that their Italians are constantly being crossed with blacks.

CARNIOLAN BEES.

This race, from Carniola, Austria, is not generally used in Massachusetts. Many who were interested when it was first introduced into America tried it and since discarded it; but 34 persons, or 3 per cent, reported having it in 1906.

OTHER RACES.

Practically every other race of bees known in the United States is on trial in Massachusetts. Several mention the newly introduced Caucasians. The Punic, Cyprian, and Banat bees are also reported.

Considering the races by localities in the State, it is difficult to see that either the Italians or the Germans are more common to any one section than to another. Italian blood tends to predominate. Personal observation, however, shows that hybrids or the more purely German are found in the back country, where newer methods of bee keeping usually receive less attention; the pure Italians and more recently introduced races are found near the large communities.

TABLE VI.—*Prevalence of different races of bees.*

	Italian.	Hybrids.[a]	Black or German.	Carniolan.	Other races.
Number reporting	594	342	196	34	....
Percentage	50	30	16	3	1

[a] Hybrids are largely an admixture of Italian and German races.

HIVES.

In 1852 Langstroth patented his movable-frame hive, which marked the beginning of modern bee keeping. In the same year he moved from Philadelphia, Pa., to Greenfield, Mass. Bee keeping was then in a deplorable condition, as he remarked, most of the hives in use being those impractical devices classed under the names of "box hives," "patent hives," and the like. According to the writer's observations, these old-fashioned hives are fast being replaced by frame hives; colonies in box hives in the country are being exterminated by disease; they are also bought up for transferring and for use in cucumber greenhouses; at present, bee keepers seldom, if ever, start with anything but frame hives. Of those who reported the kind of hive which they use, 10 per cent have exclusively box hives and 8 per cent more acknowledge having a few. Moreover, there are a thousand persons who did not reply, and it is fair to presume that a considerable percentage of these have box hives. It will, consequently, not be exaggerating to estimate that 25 per cent, and possibly 30 per cent, of the bee keepers of Massachusetts still use these hives to some extent. Lamentable, too, is the fact that the apiaries in Berkshire County, against the New York State line, are perhaps in worse condition, so far as the box-hive problem is concerned, than other apiaries of the State, for figures show that one-third of the bee keepers of Berkshire County are using the old-fashioned hive. This circumstance is particularly unfortunate because the flora promises good honey production; and again because this is a border-line county, which may serve, with its high percentage of box hives in which diseases are controlled with difficulty, as a source of bee diseases in both States.

The condition on the whole is hopeful—90 per cent of those reporting have largely or exclusively frame hives, which shows a progressive tendency.

It is not, however, within the province of this paper to discuss the relative merits of the various frame hives which are in use. The several makes and patterns in principle are the same; they vary only in detail of construction and proportion. Climatic conditions, the methods of the bee keeper, whether for comb or extracted honey—in a word, the needs of the individual should govern his selection.

By far the most popular hive is the one generally used in the United States, perfected by Langstroth. In its simplicity and proportions it has proven satisfactory to the climate of Massachusetts. Two sizes, the 8 and the 10 frame hives, are popular. According to the statistics, the 8-frame hive is more common (340 bee keepers report having it) than the 10 frame (260 bee keepers). There is a rather strong tendency, judging from remarks in the reports, toward the 10-frame hive.

Another 10-frame hive, devised in Franklin County, has a shorter and deeper frame[a] than the standard, and is second in popularity. Its use is rather local, however, being confined largely to central and western Massachusetts, where 100 bee keepers report having it.

There is but one "closed-end frame" hive in use to any extent. Seventy-seven bee keepers are using it.

Besides these three types and the box hive, there are a great many homemade contrivances and a few patent hives with some merit.

WINTERING.

METHODS.

Bees are wintered in two ways. By far the most common and at the same time least laborious and less efficient in the latitude of Massachusetts is on the summer stands. The writer has seen bees go through a winter in Massachusetts unprotected, without bottom board and the corners of the hive rotted away. All manner of devices for protecting the bees on the summer stands are used. They are packed, put in winter cases, and wrapped in paper. But the safest method in a climate as famous for severe and variable weather as that of

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[a] The frame is 14 inches long and 10¾ inches deep, with a top bar one-half inch thick, 1 inch wide, and 16⅛ inches long, with the corners clipped at each end. The ends of the frames are one-half by seven-eighths inch, and the bottom bar is one-fourth by seven-eighths inch.

Massachusetts is to winter in the cellar. Unfortunately, many of those who attempt it are not altogether proficient. Of those who have reported their method of wintering only 13 per cent winter their bees in a cellar. It is well established that by proper cellar wintering the loss in northern countries may be reduced to a minimum. In order to do this properly the bee keeper must be painstaking and observing; he must use a dry cellar and maintain as nearly a uniform temperature as possible.

MORTALITY.

In New England and the Northern States loss during severe winters may run as high as 70 per cent. This loss is greatly reduced in favorable winters, when it is as low as 10 per cent. Were all the bee keepers competent and careful, this loss might generally be reduced to 2 or 3 per cent.

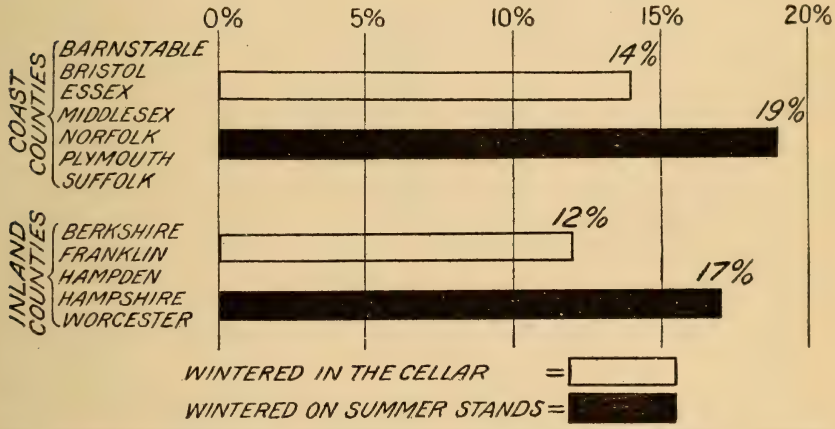

FIG. 1.—Proportionate loss of bees wintered in cellars and on summer stands. (Original.)

In the winter of 1906–7, which was not especially severe, the damage amounted to 16 or 17 per cent (see fig. 1); although this was not disastrous, it was too great a loss. It taxed the bee keepers of the State $4,886, valuing each colony at $3.50. With plenty of stores and proper protection it would not be expected that one-sixth of all the bees in the State, 1,396 colonies, should succumb during winter. The loss was most severe in localities where disease is now known to exist, which suggests that the excessive loss in a measure resulted from the depletion of colonies by disease.

BEES IN GREENHOUSES.

The use of bees in cucumber greenhouses is one of the many phases of bee keeping, perhaps the most prosperous or certainly that most peculiar to Massachusetts. The industry is little known outside of this State, yet growers in other Atlantic and Central States have undertaken it to some extent. Originating in Worcester County, it has assumed large proportions through the eastern part of Massachusetts. The accompanying map (fig. 2) shows the approximate location of the industry. It is a difficult task to obtain satisfactory data on this phase of apiculture. Market gardeners who grow cucumbers under glass do not consider themselves apiarists; on this ground they largely disregard requests for information. Only through a personal canvass among the growers has information been obtained.

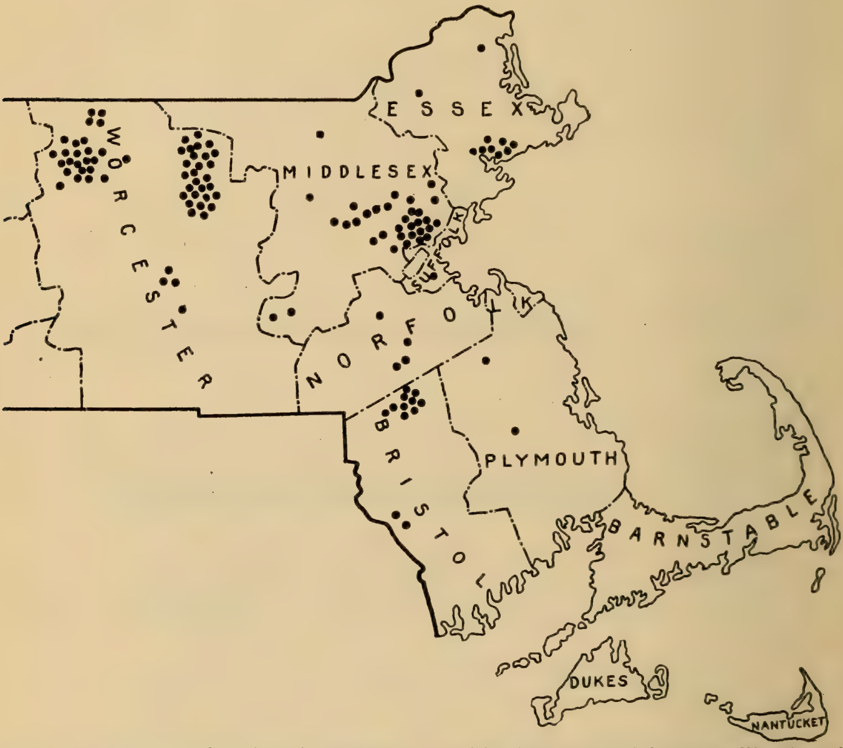

FIG. 2.—Approximate location of greenhouses in which bees are used for the pollination of cucumbers. (Original.)

There are at least 118 greenhouse cucumber growers. Only 73 of these, however, have furnished definite figures. These growers, including some of the largest and many of the smaller producers, use on an average 8 colonies of bees a year to set the crop. If the 118 known growers, which is not by any means the total number, require on the average 8 colonies each, nearly a thousand hives of bees would be utilized annually and, if the statistics from every grower were at hand, the writer feels sure several hundred colonies more than a thousand would be needed. When it is considered that practically all of these colonies are totally ruined while in the greenhouses and that the demand for bees is on the increase each year, it may be readily seen what excellent opportunity there is of producing bees for greenhouse use. Considering the recorded sale of bees in 1906, which amounted to 1,027 colonies, it is probable that these sales must have been largely a result of the demand for greenhouse use. In illustration of the extent to which bees are used for this purpose it may be mentioned that one grower who picks 10,000 bushels annually requires 80 colonies of bees; another having 40 acres under glass requires 35 to 40 colonies; a great many of the smaller growers use from 5 to 20 colonies. Cucumber growers, as a class, know little of bee-keeping methods, but they are anxious to learn. They feel that they must, in the stress of competition and high expenses, reduce the cost and loss in bees.

Bees are introduced into the greenhouses as soon as the cucumber vines begin to bloom. If the houses are large, two or more hives, according to the area of the house, are placed on boxes on the beds or hung in the gables of the house. Various other methods of introducing the hives are also employed. Not being able to secure sufficient stores in the winter, the colonies dwindle or become depleted in seven or eight weeks or less. It is a common practice among the growers to feed their bees sugar sirup or other sweets. Besides not being able to secure nectar to any extent from the cucumber blossoms, the bees are also unable to gather much pollen, which is probably a factor in the rapid depletion of the colonies. During the spring and summer, however, bees in the houses fare better, because they are able to escape, through ventilators and lights of glass removed for their exit, to the fields, where they secure nectar and pollen. Even under these circumstances the writer has seen colonies with no stores, with only a handful of bees and with scattered and half-starved brood. It is not surprising under such conditions that bee moths are such a great annoyance. To an experienced bee keeper the reason for their presence is obvious; when a colony becomes weakened the moth gains headway on the combs. No remedy for the moth in dwindled colonies can be suggested save killing the larvæ as they appear in the hive. A means of keeping the colonies strong must first be looked for, which will relieve the bee-moth nuisance. Without doubt, however, the pest could be reduced if the greenhouse men would be more careful in disposing of hives in which the bees have died. The moths breed by thousands in discarded hives, and later are at hand to infest fresh material. Under no circumstance should discarded combs be cast outside on the rubbish heap to be devoured by the bee moths. Such a practice is a menace to bee keepers for miles around.

TABLE VII.—*Distribution of greenhouse cucumber growers and record of bees used in greenhouses.*

County.	Number known to be engaged in cucumber growing.	Number reporting.	Number of colonies of bees known to be used annually.
Bristol	12	7	140
Essex	10	2	15
Middlesex	33	21	244
Norfolk	4	1	50
Plymouth	2	1	20
Suffolk	1	1	15
Worcester	56	40	100
Total	118	[a]73	[b]584

[a] Average of those reporting, 8.

[b] Estimated total, 944.

THE BEE MARKET.

It is doubtful whether in any other State in the Union more colonies of bees are sold, in proportion to the number on hand in the spring, than in Massachusetts. As is pointed out, the cucumber industry has much to do with this. Although there are many small, more or less amateur bee keepers in the State who customarily sell their surplus colonies, the trade is not at all confined to them. The supply houses and commercial bee keepers sell heavily, which is remarkable in a region where there is so little bee keeping on a large scale. Peculiarly, every county in the State shares in the trade about equally, in proportion to their respective number of colonies. The table, arranged from the statistics of 1906, shows that the bee keepers of Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, and Worcester counties sold approximately one-fifth of all the colonies on hand in the spring. Plymouth County, however, took the lead, selling 39 per cent, while in the remote counties of Barnstable and Berkshire, and in the metropolis county, Suffolk, the sale was relatively light.

TABLE VIII.—*Number of colonies sold as compared with colonies on hand in spring of 1906.*

County.	Number of colonies of bees.		County.	Number of colonies of bees.	
	Spring of 1906.	Sold in 1906.		Spring of 1906.	Sold in 1906.
Barnstable	185	1	Hampshire	408	46
Berkshire	495	29	Middlesex	962	142
Bristol	321	80	Norfolk	364	72
Essex	531	107	Plymouth	463	170
Franklin	491	102	Suffolk	57	3
Hampden	366	73	Worcester	1,199	202

PRICES OF BEES.

Figured on a basis of $5 a colony, which is an exceedingly low average price, the total sales reported for 1906 would have amounted to $5,135; at $6 per colony they would have amounted to $6,162, which more justly represents transactions. Colonies of bees sell as low as $2, or, if they are in a nail keg or soap box, for $2.50; at about $3 if in a regular box hive; and from $4 to $10, according to the race, strength, and season, if in frame hives of standard patterns; a usual price is $6. The customer sometimes furnishes an empty hive to the bee keeper, in which to hive a swarm. Such swarms bring about $3.

THE QUEEN TRADE.

Besides a trade in colonies of bees, there are several persons interested in commercial queen rearing. All but three of these, however, do a relatively local business. On account of late and cold springs, Massachusetts is handicapped in producing early queens for market which shall compete with those raised in the South. The prices prevailing throughout the country—75 cents, $1, and up—are charged for queens produced in Massachusetts. It is difficult to calculate just how many queens are reared for sale, but an estimate of 500 may not be far from correct.

'ENEMIES.

The only enemy which is formidable in all parts of the State, but which is not detrimental to progressive bee men, is the bee moth, *Galleria mellonella* L. This insect, however, has been credited by all the early apiarists, Langstroth included, with devastating, crippling, and practically annihilating the bee-keeping interests throughout New England. According to Edmund Smith,[a] it first took hold in eastern Massachusetts about 1800. In 1805 it reached Connecticut. Thence it spread westward. Writers—as, for instance, Smith—were formerly inclined to consider the moth as a formidable enemy. Smith says: "For a time, wherever it appeared it nearly destroyed the bees. At first it was more fatal than it has been since." The inroads of the moth led to all sorts of claptrap devices in the form of "patent hives" to protect the bees from the pest. But there is serious doubt, in view of recent discoveries of the relation of moths and bee disease, if this historical disaster was really due to the moth. There is good reason to believe moths were secondary, while disease, not then understood, was primary. This matter is more fully discussed in a former paper.[a] The moth does not materially damage strong, healthy colonies, but is a menace only to persons who are inattentive to their bees or who are careless, leaving empty combs about their hives and bee yards, and who fail to recognize and to treat bee diseases. Combs not in use or not covered by bees should be fumigated with carbon bisulphid and sealed in tight boxes for storage.

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[a] Smith, Edmund, Chairman. 1864. Bee Culture, Essex. From the report of the Committee on Bread and Honey. Abstract of the returns of the agricultural societies of Massachusetts. Bound together with Eleventh Annual Report of Secretary of Massachusetts Board of Agriculture, pp. 221–229.

DAMAGE TO THE BEE-KEEPING INDUSTRY BY THE GIPSY MOTH (PORTHETRIA DISPAR) AND BROWN-TAIL MOTH (EUPROCTIS CHRYSORRHŒA).

Numerous complaints came from eastern Massachusetts, where gipsy and brown-tail moths are doing tremendous damage to forest and shade trees, that they were causing a loss to the apiarist as well. Damage is done both directly to the bees and indirectly to the honey flora.

From Cliftondale, Essex County, one bee keeper says that they have bothered during June and July by trying to crawl in at the entrance of his hives. Another speaks of the caterpillars having eaten up all the plants which the bees commonly forage upon, save golden-rod and burdock, and have thus caused a loss of his bees. Failure of his honey crop in 1906 is attributed to severe ravages of gipsy and brown-tail moths. The basswood of New England was formerly a good honey producer and could be counted upon for a crop, is a report from Melrose, but since the brown-tail and gipsy moths defoliated the trees it can no longer yield much. A Medford bee keeper contributes this interesting note:

> Gipsy and brown tails have so spoiled the fruit bloom, an important factor in spring building, that colonies fail to become sufficiently strong for the harvest. The willow, maple, and elm, early pollen yielders, have also suffered from the moths, which has consequently damaged bee keeping.

Another peculiar case is reported from Cliftondale. Brown-tail and gipsy moths were so thick on the trees when a number of swarms came out that the bees did not stay near the apiary.

> The trees were covered with them so that the bees would not stay to be hived. * * * In regard to the honey plants, the moths destroyed all the blossoms on the fruit trees and wild plants. Every place was covered with them each year from 1904 to 1906; the result is that there was no honey this year (1906), owing to so many of the fruit trees and honey plants being destroyed by the pest.

BEE DISEASES.

This subject has already been treated with some detail in a former paper.[b] Since the appearance of that paper, however, the extent of diseases and the damage they are doing have become more fully realized. Consequently their general distribution has been found to be even greater than was then believed.

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[a] Gates, Burton N. 1908. Bee Diseases in Massachusetts. Bul. No. 75, Part III, Bureau of Entomology; Bul. 124, Mass. Agr. Exp. Station.

[b] Ibid, pp. 23–32; also Bul. No. 124, Agr. Exp. Station, Amherst, Mass.

BEE KEEPERS' ORGANIZATIONS.

Bee keepers' societies, fairs, institutes, conventions, and the course of instruction in bee keeping at the Massachusetts Agricultural College at Amherst are strong factors in the advancement and progress of apiculture in Massachusetts. The societies bring together the practiced and proficient bee keepers in several sections of the State. The instruction at Amherst reaches a few, largely beginners, each year; conventions and institutes bring together the new and the old bee keepers from over a large area for consideration of present-day problems; the State and county fairs and agricultural shows educate the public and benefit the industry.

There are at present two societies organized in the interest of promoting bee keeping. The oldest is the Worcester County Bee Keepers' Society, organized April 14, 1900. Meetings are held monthly throughout the winter months. At least once each summer there is a field meeting and institute. Since 1906, in the fall of each year, a " bee show " or fair is held at Worcester, where are held competitive exhibits of bees, products, supplies, etc. There is usually a series of lectures in connection with the fair.

The other society is the Massachusetts Society of Bee Keepers, which was organized March 24, 1906, when the Massachusetts Apicultural Society was disbanded. Meetings are held in Boston once each month during the winter.

Another society, to be called the Franklin, Hampshire, and Hampden Bee Keepers' Association, was provisionally organized at an institute meeting of the Massachusetts State Board of Agriculture at Ludlow, Mass., July 21, 1908.

INSTRUCTION IN BEE KEEPING.

At the Massachusetts Agricultural College, Amherst, there is given each year, beginning the fourth Wednesday in May and continuing two weeks, a course in apiculture, which is free to those who enroll. The course includes excursions to apiaries of peculiar interest, lectures, and practical demonstration and practice.

CONVENTIONS.

The Massachusetts State Board of Agriculture is exceedingly interested in promoting bee keeping and holds several institutes each year, usually with the bee keepers' societies. Several papers on bee keeping, enumerated in the appended bibliography, have been published by the board.

SUMMARY.

As early as 1644 the colonies made a beginning in apiculture in Massachusetts. More than two centuries passed, however, before modern bee keeping began, which came with the invention of the frame hive by Langstroth in 1853. To-day there are more than 2,100 persons in the State who derive some profit from their bees. The bee keepers who reported in the spring count of 1906 had 5,839 colonies, or an average of 5.5 colonies. Massachusetts needs fewer but more proficient bee keepers, who will undertake their work along business lines. The major part of Massachusetts is quite as inviting and promising as Vermont and New York State, where bee keeping is more profitably conducted.

There are but three persons who report 75 to 100 colonies in their yards, and but two who have more than 100 colonies. The number of amateur bee keepers is reduced through the dropping out of 50 per cent of the beginners during the past five years.

In the production of honey and possibly of wax the effect of an excess of semiproficient bee keepers is again apparent. In 1906 the honey crop reported was 145,257 pounds, which is the largest recorded for the State. But this is small when it is remembered that in the West single individuals frequently produce in a single year from a quarter to a third more honey than Massachusetts' total annual harvest. The crop would have been materially heavier if those who reported had even approached the standard average of 35 pounds instead of having harvested only 24 pounds. This lowering of the average crop is in a large measure due to the great number of non-progressive small bee keepers and to the presence of bee diseases.

The more important honey sources, as reported by the bee keepers in all parts of the State, are clovers, golden-rod and asters, fruit bloom, basswood, wild raspberry and blackberry, sumac, and locust. Some other plants, such as clethra and huckleberry, are of local importance and some listed as of minor importance are probably underestimated.

The Italian race in varying degrees of purity is most popular. The German or "black" still persists, but is rarely found pure.

Twenty-five per cent of the bee keepers still use box hives to some extent. The presence of box hives is most noticeable in the back country, where modern methods penetrate less rapidly. Of the frame hive types, the one standard for the country, the Langstroth, is most generally used.

The loss in the winter of 1906–7 was 16 to 17 per cent, which taxed the bee keepers nearly $5,000. By far the majority winter their bees on summer stands, protected in various ways or unprotected. A few take advantage of cellar wintering, but most of those who follow this practice are not especially proficient.

A thousand colonies or more are annually used in cucumber greenhouses. Since practically all of these colonies are useless after coming out of the houses, there is a constant demand and sale for bees. Several greenhouse men use from 40 to 80 colonies a year. The average number reported is 8 colonies. In the sale of bees the several counties, exclusive of Barnstable, Berkshire, and Suffolk, sold in 1906 approximately one-fifth of all their bees, spring count. In Plymouth County the sale amounted to 39 per cent. The total income amounted to between $5,000 and $6,000. The queen-rearing industry is limited to a few persons and late springs make it difficult to compete with southern producers.

The chief enemy reported is the bee moth. There is great doubt, however, if the damage attributed is really and primarily due to it. There is, on the other hand, sufficient reason to believe that disease is primary and that destruction by the moth is secondary. Gipsy and brown-tail moths are also reported as interfering severely with apiculture in the eastern part of the State.

Massachusetts is particularly fortunate and in some ways in advance of other communities in her bee keepers' institutions. Not alone do local societies aim to promote bee keeping, but the State Board of Agriculture, State Experiment Station, and Agricultural Station as well, are deeply interested in the advancement of apiculture.

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DIV. INSECTS.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 75, Part II.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

WAX MOTHS AND AMERICAN FOUL BROOD.

BY

E. F. PHILLIPS, Ph. D.
In Charge of Apiculture.

Issued December 31, 1907.

234755

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

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U. S. D. A., B. E. Bul. 75, Part II. A., December 31, 1907.

MISCELLANEOUS PAPERS ON APICULTURE.

WAX MOTHS AND AMERICAN FOUL BROOD

By E. F. Phillips, Ph. D.,
In Charge of Apiculture.

INTRODUCTION.

It has generally been held by bee keepers that, while the wax moths often cause considerable damage by destroying surplus combs and in other ways, they were not an unmixed evil, for by destroying combs infected with brood disease they were supposed to remove the infection. Text-books on apiculture and articles in various bee journals have repeatedly reiterated this statement. Evidently no person has seen fit to look into the question thoroughly, and it is the object of the present paper to record some observations which have been made.

When a bee larva dies from infection of American foul brood, it decays rapidly, and the mass becomes ropy, so that if a small stick or pin is inserted in the decayed mass and removed, the larval material adheres to it and will string out for an inch or more. This ropiness of the dead larva is very characteristic of this brood disease. Seemingly this ropiness makes it impossible for the bees to remove the infected material, and when the decayed mass dries down it forms a scale which adheres so tightly to the lower side wall of the cell that it can not be removed without tearing the wax wall.

As the disease progresses in the colony the various cells of the brood chamber come to contain diseased larvæ and, later, scales formed of dried larvæ. It is probable that after a cell once comes to contain a diseased larva, it is almost impossible for another larva to reach maturity in a healthy condition, consequently the number of bees which reach the adult condition is constantly reduced and, as the old field bees die and are not fully replaced, the colony becomes weakened and finally dies out completely.

As long as the colony is strong the wax moths can do no damage, but as the bees decrease in number the combs offer a foothold to one or other of the moths and within a very short time the whole hive is one mass of wax moth tunnels, larval excreta, and cocoons. The combs are completely destroyed and nothing remains but the web and a mass of débris on the hive bottoms. If the moth larvæ actually ate the infected material, they would serve to remove the infection where the bee keeper is too careless to do so—as is too frequently the case.

The two wax moths differ greatly in their habits in some respects, but it is not the purpose of this paper to discuss these points. The large wax moth (*Galleria mellonella* L.) is the most widely distributed and is found in practically every part of the United States, and probably wherever the honey bee is now kept. The lesser wax moth (*Achroia grisella* Fab.), on the other hand, is not so widely distributed, but it is known to exist in various localities in this country.

WORK OF THE LARGE WAX MOTH.

(*Galleria mellonella* L.)

Plate I is from a photograph of a comb, infected with American foul brood, on which larvæ of the large wax moth were placed. The comb was placed in a box to exclude light and was laid flat on a piece of paper. The larvæ at first worked on the under side of the comb, but gradually they got to the upper surface. It will be noticed that in one part of the comb the lower side walls of the cells remain intact; here the dried-down scales of American foul brood were thickest, and evidently this was the center of the brood during the time of infection. The remainder of the area formerly occupied by comb is nothing but débris, with a few scales scattered here and there. Evidently only where scales are thick do they hold together enough to stand upright. To show how the scales stand up, the web was removed from the surface. The background of the photograph is merely a piece of paper.

Plate II is a photograph of a rough box used for a hive during some experiments in producing American foul brood by the feeding of pure cultures of *Bacillus larvæ*.[a] The five frames of this small hive contained thousands of the dried-down scales so characteristic of this disease. The box was put away in a closet and the large wax moth got into it, with the result that all the combs were completely destroyed. The webs and empty frames were removed for this photograph. The black mass in the bottom of the box is composed of

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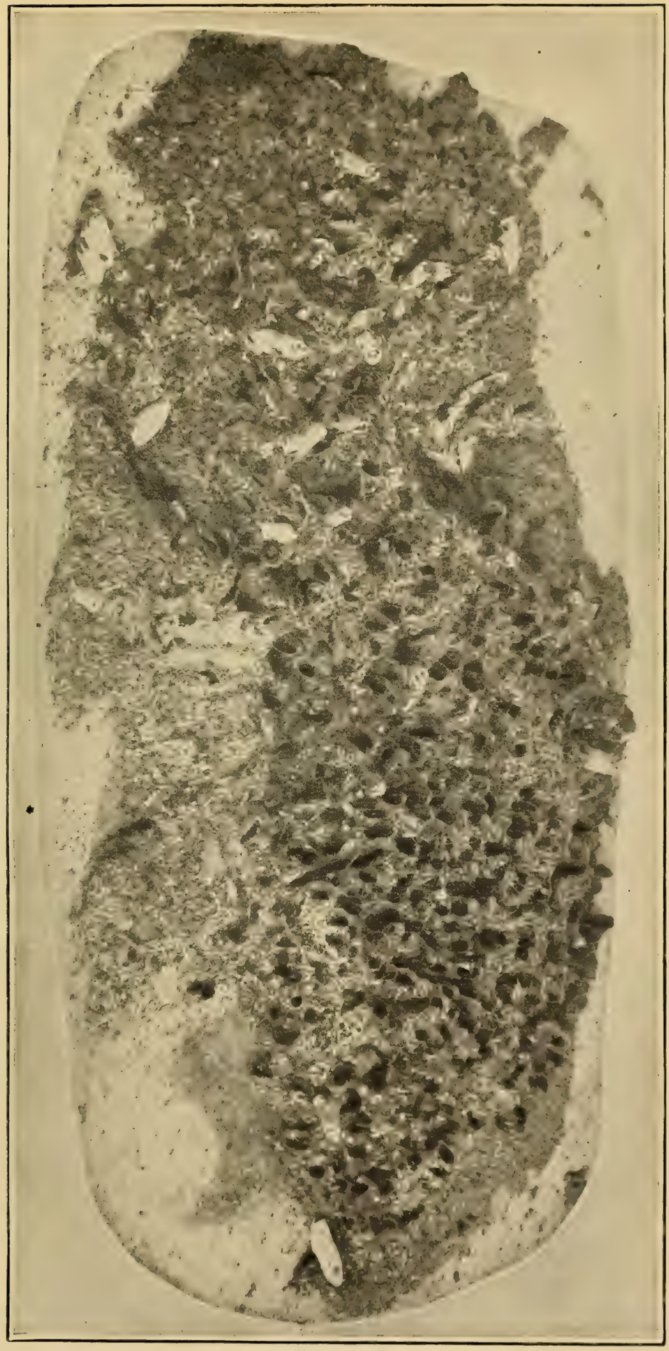
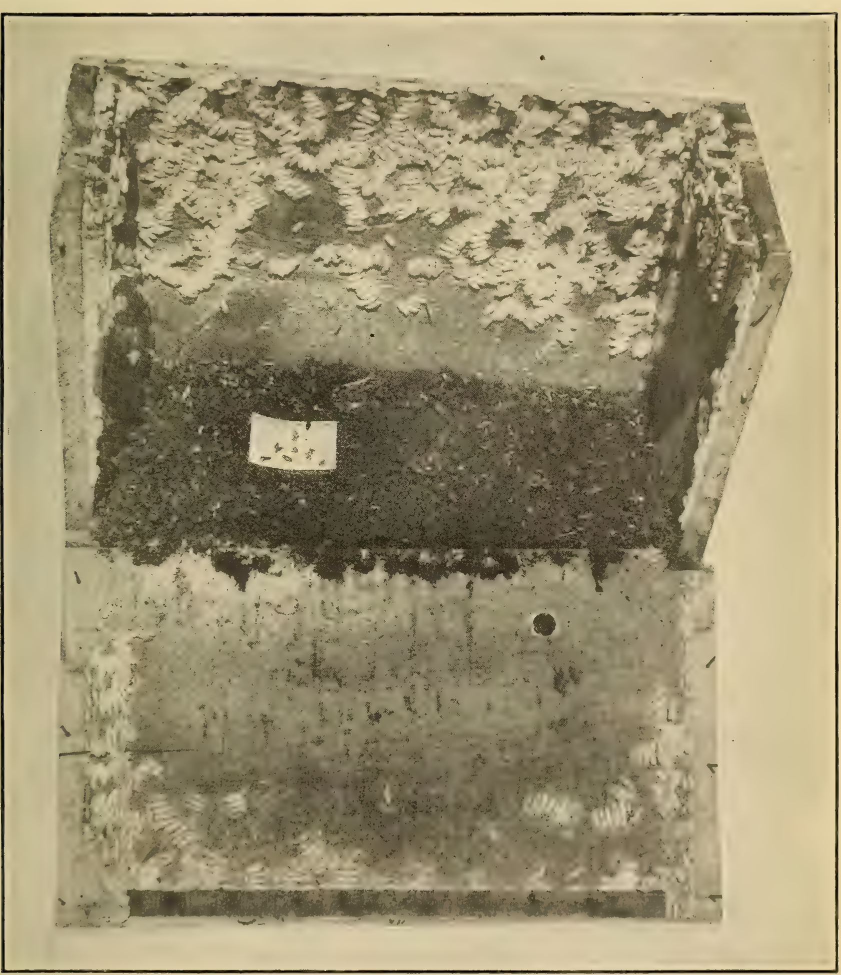
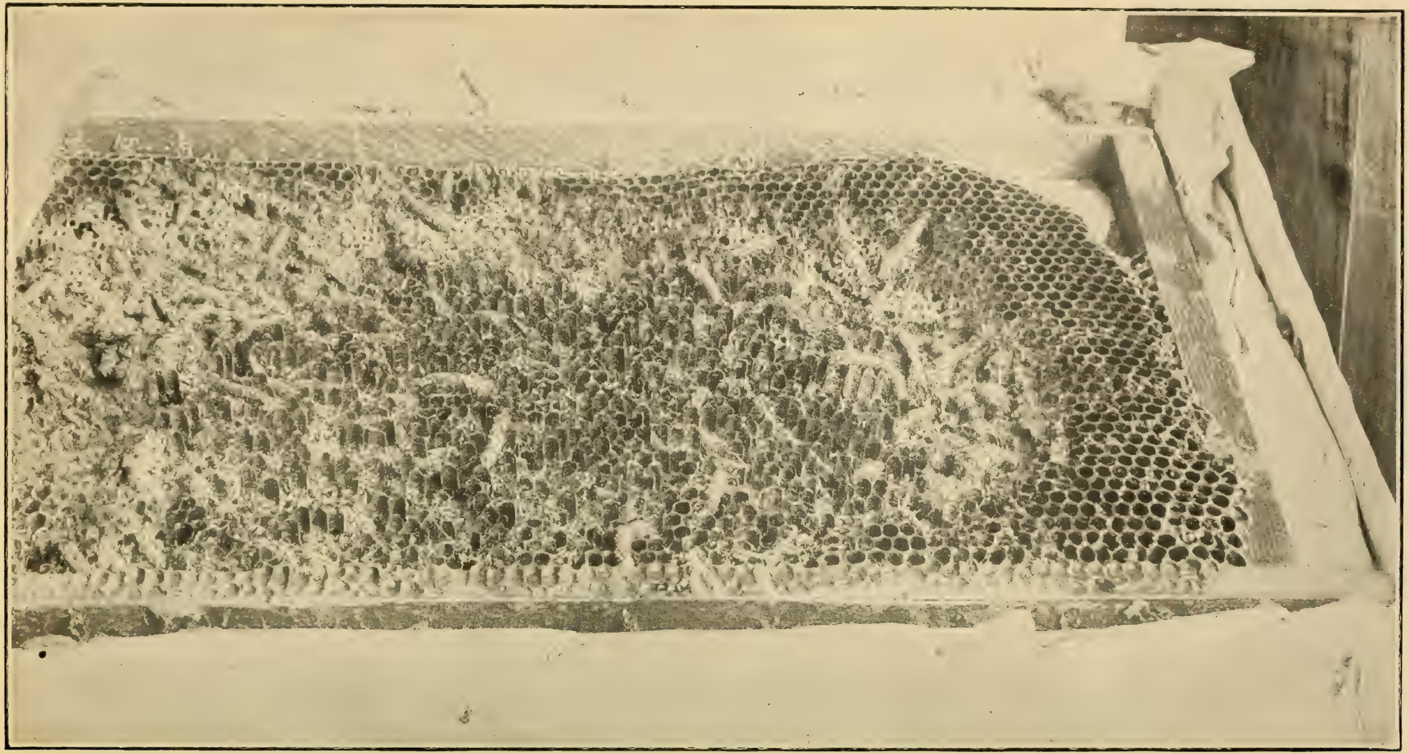
[a] Circular No. 94, Bureau of Entomology, entitled, "The Cause of American Foul Brood," by Dr. G. F. White. Issued July 29, 1907.



Work of the Large Wax Moth (Galleria mellonella) in Comb Infected with American Foul Brood. (Original.)



HIVE INFECTED WITH AMERICAN FOUL BROOD, THE FRAMES REMOVED TO SHOW WORK OF THE LARGE WAX MOTH (GALLERIA MELLONELLA). (ORIGINAL.)



WORK OF THE LESSER WAX MOTH (*ACHROIA GRISELLA*) IN COMB INFECTED WITH AMERICAN FOUL BROOD. (ORIGINAL.)

larval feces and scales in about equal proportion by volume. On account of the reduction of the photograph the scales do not appear plainly; nevertheless, this demonstrates what becomes of the scales of American foul brood in a set of combs destroyed by *Galleria mellonella.* A few scales are seen placed on a card resting on the mass of feces and scales.

Mr. Burton N. Gates, of this Bureau, took some of these scales and put them in a small box with small larvæ of *Galleria mellonella.* The scales remained untouched and the larvæ died, evidently of starvation.

WORK OF THE LESSER WAX MOTH.

(*Achroia grisella* Fab.)

Plate III is a photograph of a comb taken from a colony which had died of American foul brood. It was obtained by the author in June, 1906, near Fillmore, Ventura County, Cal., and is of interest as coming from an apiary which in less than two years had been reduced from about 200 colonies to 15 by the ravages of this disease. When the apiary was visited there were 151 hives in place, and of these 136 contained no bees. This comb was wrapped up and put away for future study, but became infested with *Achroia grisella.* Whether it contained eggs when taken in the apiary or whether the moths entered after the comb reached Washington is not known.

It is obvious from this illustration that the larvæ have not eaten the scales formed by dried-down larvæ which died of American foul brood. This comb was not cleaned of webs and illustrates very nicely the characteristic work of this moth.

After the photograph was taken the scales were picked out of the frame and this material was used in some of the inoculation experiments recorded in Circular No. 94; obviously, therefore, the material was still infectious.

CONCLUSION.

In the control of brood diseases of bees the constant reinfection of apiaries from diseased combs of colonies in a wild state is one of the things which must be combated constantly. It is not difficult for a bee keeper to rid his own apiary of disease, but he must constantly watch for an introduction of the disease from wild bees or an adjoining apiary. If then the wax moths actually destroyed the infected combs of wild colonies or of colonies in the apiaries of careless bee keepers, they would be a benefit to the industry to that extent. Naturally if the moth larvæ eat out everything except the scales and these drop to the bottom as shown in Plate II, they are less available to other bees. If sufficiently covered with débris, they are to some extent removed from robbing workers.

These results prove conclusively that the two wax moths, *Galleria mellonella* and *Achroia grisella*, do not eat the scales formed from larvæ which have died of American foul brood. It is clear, therefore, that infectious material in a colony dying of this disease remains even after the comb is destroyed. The one point in favor of these moths, from a bee keeper's standpoint, is therefore disproven.

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DIV. INSECTS.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 75, Part III.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

BEE DISEASES IN MASSACHUSETTS.

BY

BURTON N. GATES,
Expert in Apiculture.

Issued June 30, 1908.

234155

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

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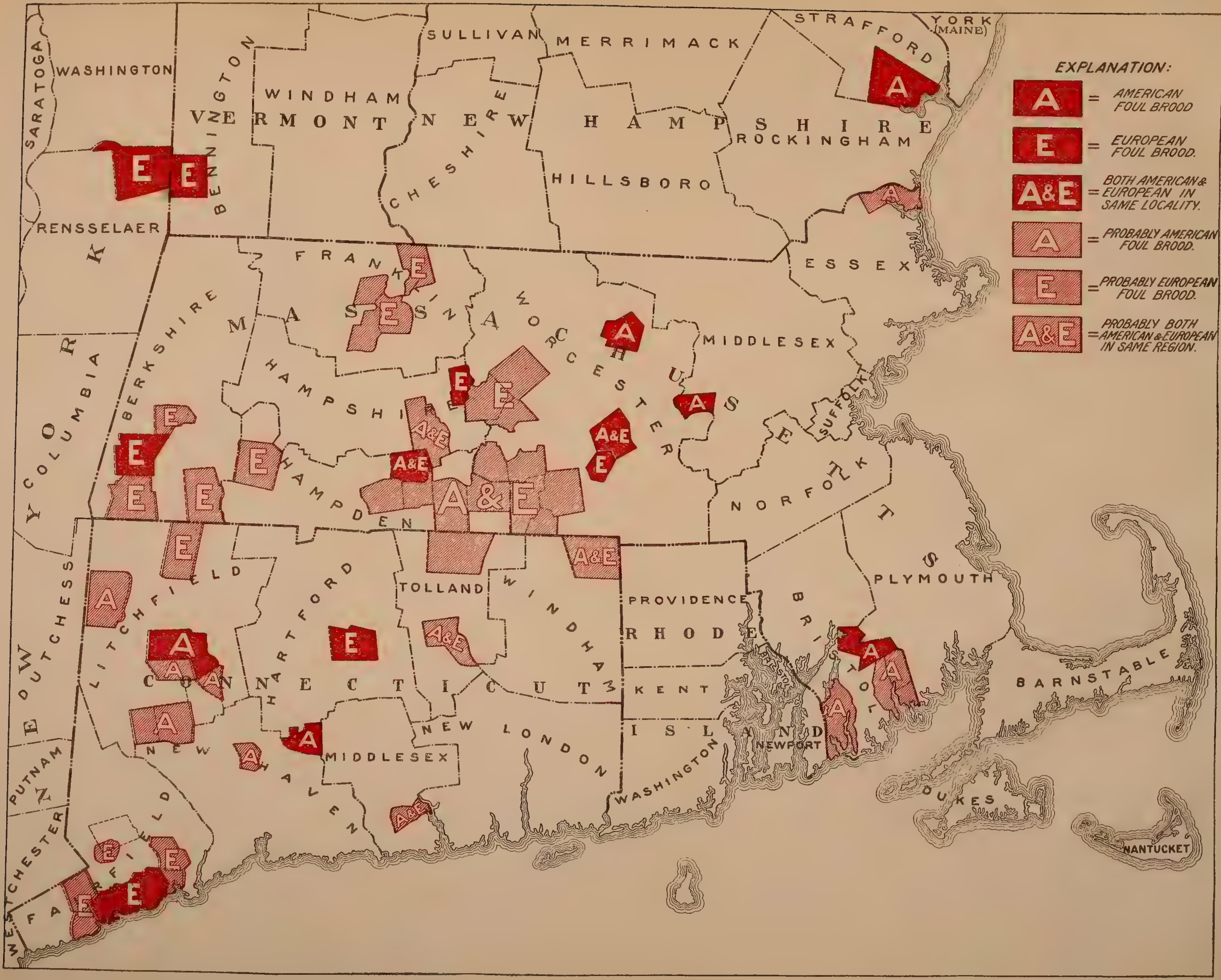
PLATE IV.



MAP SHOWING DISTRIBUTION OF BEE DISEASES IN MASSACHUSETTS AND POSSIBLE SOURCES OF INFECTION FROM NEIGHBORING STATES.

U. S. D. A., B. E. Bul. 75, Part III. A., June 30, 1908.

MISCELLANEOUS PAPERS ON APICULTURE.

BEE DISEASES IN MASSACHUSETTS.

By Burton N. Gates,
Expert in Apiculture.

INTRODUCTION.

In Massachusetts bee keeping is not an industry conducted by a few, as in the Hawaiian Islands, where four corporations harvested 600 tons of honey last year; but there are more than 2,100 men who derive some profit from their bees and who have interests at stake. There is besides, a vast, concentrated, and steadily increasing population which, fortunately for bee keepers, provides an almost unlimited home market. In order to point out the status of the industry, the writer estimated in 1904,[a] that two tablespoonfuls of honey per person as a year's ration is all that is now consumed, and of this less than one-fourth is produced in Massachusetts. Theoretically it is possible for Massachusetts to support approximately 40,000 colonies of bees, which could more than equal in amount Hawaii's honey crop for last year. There is reason to believe, however, that bee keeping, if it is not actually decreasing, is not progressing along with the steadily increasing population of the State. This is borne out by the general feeling among the country people that to-day there are fewer bees kept on the farms than there were fifty years ago.

One of the fundamental reasons for this condition may be found in the presence of brood diseases of bees, which exist in practically every quarter of Massachusetts and Connecticut, as well as in the other New England States, and which from time to time have doubtless killed out the bees in many localities. There is undeniable proof of this; furthermore, from evidence of former outbreaks it must be concluded that their introduction is not recent. This evidence is not merely the result of bee keepers' reports or of more or less semiauthoritative and indefinite rumors, but it is based upon results of bacteriological findings in numerous samples of brood comb sent to this Bureau by the bee keepers in the State during the past year and a half. Under these conditions bee keeping can not be brought to the high degree of perfection which is possible. No factor in bee keeping tends to limit the industry as do epidemics of such diseases; they cause bee keepers to become discouraged by "bad luck" and to lose interest in their bees. The "luck" must change; the bee keepers must learn the nature of the diseases, where they exist, and how to combat them; otherwise the industry will decrease even more.

---

[a] Bee Keeping: How to Meet its Dangers and Difficulties. By Burton N. Gates, with suggestions by Prof. C. F. Hodge. Fifty-second Ann. Rept. Sec. Mass. St. Bd. Agric., pp. 411–426, Boston, 1905. Massachusetts Crop Report, Vol. 17, No. 6, October, 1904, pp. 30–40. Boston, 1904.

THE TWO KNOWN BEE DISEASES.

Two contagious brood diseases of bees are now known. These attack the developing brood and so reduce it that the colony soon dwindles from lack of young bees to replace the old. They are known, respectively, as American foul brood and European foul brood.

AMERICAN FOUL BROOD.

The cause of this disease is definitely known to be an organism, *Bacillus larvæ* White. It is what has been heretofore frequently designated simply as "foul brood." The nature of the disease is described by Dr. E. F. Phillips, in charge of apicultural investigations in this Bureau,[a] as follows:

> When the larvæ are first affected they turn to a light chocolate color, and in the advanced stages of decay become darker, resembling roasted coffee in color. Usually the larvæ are attacked at about the time of capping, and most of the cells containing infected larvæ are capped. As decay proceeds these cappings become sunken and perforated, and, as the healthy brood emerges, the comb shows the scattered cells containing larvæ which have died of disease, still capped. The most noticeable characteristic of this infection is the fact that when a small stick is inserted in a larva which has died of the disease, and slowly removed, the broken-down tissues adhere to it and will often stretch out for several inches before breaking. When the larva dries it forms a tightly adhering scale [of characteristic and diagnostic shape and] of very dark brown color, which can best be observed when the comb is held so that a bright light strikes the lower side wall [of the cell]. Decaying larvæ which have died of this disease have a very characteristic odor which resembles a poor quality of glue. This disease seldom attacks drone or queen larvæ.

EUROPEAN FOUL BROOD.

This is the disease which appears to be most prevalent in Massachusetts, probably having swept in from New York State, where it was formerly known as "black brood." Its presence is less easily diagnosed by superficial examination than is American foul brood. It is described by Doctor Phillips[a] as follows:

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[a] The brood diseases of bees. By E. F. Phillips, Ph. D. Circular 79, Bureau of Entomology, U. S. Department of Agriculture, pp. 1–2, 1906.

> This disease attacks larvæ earlier than does American foul brood, and a comparatively small percentage of the diseased brood is ever capped. The diseased larvæ which are capped over have sunken and perforated cappings. The larvæ when first attacked show a small yellow spot on the body near the head and move uneasily in the cell. When death occurs they turn yellow, then brown, and finally almost black. Decaying larvæ which have died of this disease do not usually stretch out in a long thread when a small stick is inserted and slowly removed. Occasionally there is a very slight "ropiness," but this is never very marked. The thoroughly dried larvæ form irregular scales which are not strongly adherent to the lower side wall of the cell. There is very little odor from decaying larvæ which have died from this disease, and when an odor is noticeable it is not the "glue-pot" odor of the American foul brood, but more nearly resembles that of soured dead brood. This disease attacks drone and queen larvæ very soon after the colony is infected. It is as a rule much more infectious than American foul brood and spreads more rapidly. On the other hand, it sometimes happens that the disease will disappear of its own accord, a thing which the author never knew to occur in a genuine case of American foul brood. European foul brood is most destructive during the spring and early summer, often almost disappearing in late summer and autumn.

DAMAGE FROM BEE DISEASES.

The damage from an epidemic of bee disease is as difficult to estimate as is the damage from an epidemic of smallpox, of typhoid fever, or of malaria in a human community. The loss of colonies is but one small item; there is the resulting loss of crop, the resulting lack of increase in the number of colonies of bees, and that demoralizing effect on the industry which tends to cause bee keepers to go out of business. Besides this there is a crippling of commercial queen rearing, a check on the trade in bees, and a decisive effect on the manufacture and sale of bee keepers' supplies. All these factors must be considered in an estimate; and, what is more, the damage is accumulative. It can not be calculated by the year and then totaled; the progressive loss must be figured.

In New York State, where European foul brood has been combated for nearly a decade, and where it is now well suppressed, it has been estimated that the damage from loss of bees alone, in a very limited area, in 1899 and 1900, was at least $45,000.

In Ventura County, Cal., where American foul brood flourishes, a thriftless bee keeper had 151 colonies which, from neglect, were reduced to 14 colonies in a little over twelve months' time. One hundred and thirty-seven colonies had died or were nearly dead. But there are many more and even sadder cases, were there space to relate them.

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[a] The brood diseases of bees. By E. F. Phillips, Ph. D. Circular 79, Bureau of Entomology, U. S. Department of Agriculture, p. 2.

PRESENT EXTENT OF BEE DISEASES IN MASSACHUSETTS.

The extent of bee diseases in Massachusetts may be readily seen on the map. The towns in which they are positively known to occur are listed below in black-faced type. Towns in which they probably exist are listed in lighter-faced type.

Table showing the towns in which the bee diseases respectively occur.

[**Black-faced type** indicates where disease is positively known to exist. Light-faced type indicates that disease is probably present.]

American foul brood.		European foul brood.	
Bristol County:	*Worcester County:*	*Berkshire County:*	*Hampshire County:*
Acushnet.	Brookfield.	**Great Barrington.**	Belchertown.
Freetown.	Charlton.	Lee.	**Greenwich.**
New Bedford.	**Leominster.**	Sandisfield.	*Worcester County:*
Westport.	Sturbridge.	Sheffield.	**Auburn.**
Essex County:	Southbridge.	*Franklin County:*	Barre.
Amesbury.	Warren.	Deerfield.	Brookfield.
Salisbury.	**Worcester.**	Greenfield.	Charlton.
Hampden County:		Montague.	Hardwick.
Brimfield.		Northfield.	New Braintree.
Ludlow.		*Hampden County:*	Southbridge.
Monson.		Blandford.	Sturbridge.
Springfield.		Brimfield.	Warren.
Wilbraham.		**Ludlow.**	**Worcester.**
Hampshire County:		Monson.	
Belchertown.		Springfield.	
Middlesex County:		Wilbraham.	
Marlboro.			

The distribution of these diseases is based, as is explained, on bacteriological findings in numerous samples of suspected brood, submitted by the bee keepers during the past year and a half. The examinations were made by Dr. G. Franklin White, expert in bacteriology, of this Bureau. In plotting the regions where disease is thus definitely known to exist a solid red color has been used. Index letters, A for American foul brood and E for European foul brood, show which disease is present in each locality.

Besides these definite data there are in the Bureau of Entomology a great number of reports from bee keepers throughout Massachusetts, which, without the definite knowledge from the bacteriological examinations, would be of slight significance and importance, but which, in conjunction with these findings, are of the greatest value. They indicate regions of probable infection, which are shown on the map in lighter tone.

As an illustration, a bee keeper who lives in Acushnet reports, "I lost all my bees, thirty swarms, at once." This bare statement is of slight import; but taken together with the fact that American foul brood occurs in Freetown, it would indicate that American foul brood is distributed throughout southern Bristol County. Another illustration is found in Worcester County. Bacteriological examination shows that in Auburn and Worcester both European foul brood and American foul brood exist. A bee keeper from Barre reports that in the year 1902 or 1903 he lost forty-five colonies of bees. From East Brookfield and Charlton, from New Braintree, Sturbridge, and Warren, all located around and adjoining Worcester and Auburn, reports of heavy loss of bees, not alone by one bee keeper in a town but by several, are at hand. A bee keeper in Warren says, "Bees all died about five years ago; I had nine colonies which I lost; Mr. —— lost about five colonies also, as did others, so that at the present day only three to four colonies remain in town." Similar reports come from across the county and Connecticut State lines adjoining this section of Worcester County. It is highly probable, then, considering the positive knowledge of foul brood in Worcester and Auburn and considering collectively the widespread and yet individual reports from the country about these two towns, that these diseases are present throughout this section of Massachusetts and Connecticut. In other parts of the State similar conclusions are obvious.

Considering the distribution as a whole, it is apparent that European foul brood has swept in from New York State, where the disease has existed for years. Moreover, were the bees in western Massachusetts systematically examined, this portion of the State would doubtless be found thickly infected with European foul brood. American foul brood in Connecticut has apparently invaded Litchfield County in the western half of the State. In Massachusetts, on the other hand, and in one small area in New Hampshire, where there is less thorough information, American foul brood is largely confined to the eastern half of the State. Ultimately, when more information is at hand, if decisive and immediate steps to suppress these diseases are not taken, Massachusetts, as well as the rest of New England, will undoubtedly reveal a mass of infection.

EVIDENCE THAT BEE DISEASES WERE NOT RECENTLY INTRODUCED INTO MASSACHUSETTS.

In 1828 Dr. James Thatcher wrote (p. 4):[a]

> The destructive ravages of the bee-moth have in many places almost annihilated our bee establishments and discouraged all attempts to renewed trials. No less than a hundred hives have, the past season, been entirely destroyed by that enemy within the towns of the county of Plymouth, and in places where a single hive has yielded one hundred pounds of honey.

At first reading this might appear, so far as bee diseases are concerned, of slight import. General experience shows, however, that strong, healthy colonies of bees are seldom if ever destroyed by wax moths, the presence of the latter being secondary as a result of a weakened condition of the colony from loss of its queen, disease, or the like. Consequently, wherever there is extensive complaint of damage from moths, there the presence of disease is to be suspected.

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[a] A Practical Treatise on the Management of Bees. * * * By James Thacher, M. D., Boston, 1829.

In 1831, again, Dr. Jerome V. C. Smith[a] says (p. 41):

> Great lamentations are heard about the bee-moth, * * * whose devastations in the New England States have been described as something frightful.

More specifically he says (p. 43):

> In the interior of Massachusetts, New Hampshire, and Connecticut the farmers have become heartily discouraged in their attempts at cultivation, and lamentably appear to have abandoned them entirely.

Such reports strongly suggest that some unknown agent, as disease, depleted the bees and made them subjects for the devastations of bee moths. Even at that early date Doctor Smith intimates (p. 41) that all the damage "attributed to it [the bee moth] . . . admits of some doubt." Without being conclusive, such evidence must be accepted as strongly indicative of the existence of disease, probably of American foul brood, in Massachusetts.

About 1896 the writer saw in Worcester a hive in which the bees had died from some affection of the brood. It was diagnosed then as a disease which is now designated as American foul brood. Only one hive out of several was affected.

European foul brood, on the other hand, is of more recent introduction in the State. It was first recognized in New York State in 1895, where it is thought to have been introduced in importations of bees from the south. As the map shows, this disease has probably spread into Massachusetts from New York.

The late Mr. James F. Wood, of North Dana, noticed in the Connecticut and Swift River valleys of Massachusetts a brood disease of bees which made its appearance in that region about 1901. It did much damage, destroying all the bees in the yards where it appeared; but, as it was apparently not American foul brood, Mr. Wood regarded it as a new disease. From a description made in an address before the Worcester County Bee Keepers' Association by Dr. James B. Paige,[b] of Massachusetts Agricultural College, who was closely associated with Mr. Wood and who made a study of the disease, it would appear to have been European foul brood. Being first observed in Massachusetts in 1901, it would have had ample time to have spread from New York State.

With so little recorded data, it is difficult to draw positive conclusions regarding the distribution of these diseases in years gone by. It is far more important, however, to realize that they have existed in the State for a considerable time, that they have been and are a decided check on the progress of bee keeping, but that they can now be counteracted.

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[a] An Essay on the Practicability of Cultivation of the Honey bee * * *. By Jerome V. C. Smith, M. D., Boston, 1831.

[b] Wood's Bee Disease. American Bee Keeper, Vol. 16, pp. 69–70, 1906.

THE SPREAD OF BEE DISEASES.

Both types of foul brood are highly infectious; the way in which they are spread might be compared to the spread of typhoid fever in human communities. Honey is the common carrier of this infection, just as milk and water are the agents which frequently spread typhoid fever.

In diseased colonies of bees, practically every part of the hive becomes contaminated with the germs of the disease. Consequently, when disease is found in the bee yard, every precaution must be taken that bees from healthy colonies do not come in contact with any part of the diseased colonies or hives. Honey, being so irresistible to the bees, is of course the main thing to be guarded. Since diseased colonies soon become weakened, from the lack of young bees to replace those dying from old age, they are less likely to maintain guard against robbers, which are a great source of danger in the spread of infection. Immediately on discovery, diseased colonies should be treated.

FEEDING HONEY.

In these days of widespread bee disease it is dangerous to feed any honey to bees; it is far preferable and less dangerous to supply them, if they need stores, with a sirup of sugar and water, half and half. It is safe to feed honey to bees only when it has been vigorously boiled for at least a half hour, and, as Doctor Phillips has recently stated,[a] in order to avoid risk, "it is better to make this an hour" (p. 12). In boiling, the honey should always be diluted with equal parts of water in order to prevent scorching.

DISINFECTION OF TOOLS AND HANDS.

All tools used in manipulating diseased bees, as well as the operator's hands, should be thoroughly disinfected before opening a healthy colony.

DEPLETED HIVES FROM GREENHOUSES A SOURCE OF DANGER.

In Massachusetts particularly there is another source of infection which is difficult of control. Each year several hundred colonies of bees are placed in greenhouses by those who grow cucumbers under glass. In the adverse conditions of the cucumber house the hive soon becomes depleted and is promptly thrown on the rubbish pile. If the hive originally came from a foul-brood region—which is not improbable, inasmuch as the greenhouse men buy their bees wherever they can get them—all the bees within a radius of several miles of the rubbish pile are exposed. More than once the writer has seen from two to a half dozen such hives cast out on the rubbish heap. While there is no intention of endangering neighbors' bees, it is as criminal to throw out of doors any hive in which bees have died as it is to shake the bedding or throw the waste of the sick room from the window. Discarded hives and their contents, if the cucumber grower does not wish to render the wax, should be thrown under the boiler.

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[a] The production and care of extracted honey. By E. F. Phillips, Ph. D. Bul. 75, Pt. I, Bur. Ent., U. S. Dept. Agric., 1907. Price 5c, from Superintendent of Documents, Washington, D. C.

PURCHASING BEES AND QUEENS.

In purchasing bees the buyer should be as certain that he is getting stock free from disease as is the farmer, who purchases cows, that these have no tuberculosis. A region where the disease is not found or where it has been successfully suppressed can be reinfected by one careless purchase. For instance, speaking of New York State, Mr. Charles Stewart says:[a]

> Just as we [the inspectors] were feeling that we had nearly stamped it [the disease] out and were masters of the situation we discovered that at least one if not two fresh importations had been made in a section of the State where no trouble of this kind [European foul brood] formerly existed (p. 55).

To some degree this applies to purchasing queen bees. It is usually safe, however, to introduce a queen if she is removed from the cage in which she is mailed and is introduced unaccompanied by her escort of workers. The candy which is shipped with queens should never be put into a hive.

STRAY BEES.

There is one agent over which the bee keeper has no control and which should cause him no anxiety if a considerable territory is freed of the diseases. It is a well-known fact that under certain conditions, as, for instance, in storms and heavy winds, bees enter hives other than their own. Obviously, then, such bees in their interchange of hives may spread the infection. This only emphasizes the urgency of cleaning the disease out of a whole State, or, better, out of a block of States, as New England. Cooperation is the key to the situation.

BROOD DISEASES CAN BE CONTROLLED.

Enumeration of the methods by which disease is spread should not convey the idea that these diseases can not be combated, for it has been thoroughly demonstrated that by judicious and persistent manipulation both of them can be successfully controlled and suppressed. The rapidity with which they spread, however, makes cooperation of bee keepers throughout the State or States essential. Sixteen States and Territories[a] now have legislation and inspectors designed to protect the bee keepers from the spread of these infectious diseases. The State nearest to Massachusetts is New York, where the annual loss of bees alone is shown in the following figures:[b]

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[a] Report of the Meeting of the Inspectors of Apiaries, San Antonio, Tex., November 12, 1906. Bul. 70, Bur. Ent., U. S. Dept. Agric., 1907.

Previous to 1899, in a limited area, the loss of bees alone is estimated at	$39, 383
In 1899, when concentrated effort to suppress bee disease was begun, it amounted to	25, 420
In 1900	20, 289
In 1902	10, 853
In 1903 the loss of the previous year was halved, making it	5, 860
In 1903 it was	4, 741
In 1904 it was again divided by two, being	2, 220
In 1905 there was again a reduction of nearly 50 per cent	1, 725
Total loss of bees, covering about ten years	110, 491

In other States the encouraging results of inspection and persistent effort to suppress the inroads of disease are similar.

INSPECTION.

Inspectors are not alone police officers. They are educators, up-to-date bee keepers giving instructions in modern methods of bee keeping, thoroughly experienced in treating foul brood, and a great stimulus to progress. They are necessarily exacting and thorough; but they are not out to seize and condemn; their aim is to help the bee keepers, to assist them in a cooperative effort to eradicate disease, and to promote bee keeping. Of course the individual can do much for himself by keeping his own yard clean and free from infection; but he is in constant danger of reinfection from his neighbors, if they fail to cooperate with him.

A BRIEF ACCOUNT OF TREATMENT FOR BROOD DISEASES.

Those who are most experienced in the suppression of brood diseases are agreed that “shaking,”[c] which is practically “shook swarming,” and modifications of this process are the only successful methods.

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[a] The legislation empowering this inspection in twelve of these States and Territories is reprinted from Bul. 61, Bur. Ent., issued November 5, 1906, and entitled “The Laws in Force Against Injurious Insects and Foul Brood in the United States,” compiled by L. O. Howard and A. F. Burgess.

[b] These figures are afforded by a compilation made in 1905 by Mr. Charles Stewart from the records of the commissioner of agriculture of New York State.

[c] The various treatments are described by Dr. E. F. Phillips in Circular 79, of this Bureau, mentioned above.

SHAKING.

Shaking is briefly this: As soon as a colony is discovered diseased, and at a time when there would be no robbing, it is shaken on the old stand into a hive containing new frames with narrow strips of foundation. In this way none of the contaminated honey is deposited in the new cells. Should the disease reappear, which is sometimes the case, the operation must be repeated. In order to prevent the bees from swarming out, the queen may be caged in the hive for a few days or the entrance closed with a piece of queen-excluding zinc. Care should be taken not to scatter parts of the contaminated hive, particularly the honey, where bees can get at them.

DISINFECTION OF HIVE MATERIALS.

Honey, unless it has been boiled as above described, should never be fed back to bees. Wax, however, after being rendered and manufactured into foundation, is commonly used without apparent danger. It is customary in the East to put bees back into hives which have formerly contained diseased colonies, after they have been thoroughly cleaned of all bits of wax and honey. In the West, however, the hives are either burned out with oil, with a blue-flamed torch, or are disinfected with strong chemical disinfectants. All frames should be burned, since it does not pay to clean them.

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DIV. INSECTS.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 75, Part IV.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

THE RELATION OF THE ETIOLOGY (CAUSE) OF BEE DISEASES TO THE TREATMENT.

BY

G. F. WHITE, Ph. D.,
Expert in Bacteriology.

Issued December 26, 1908.

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234755

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

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MISCELLANEOUS PAPERS ON APICULTURE.

THE RELATION OF THE ETIOLOGY (CAUSE) OF BEE DISEASES TO THE TREATMENT.[a]

By G. F. WHITE, Ph. D.,
Expert in Bacteriology.

INTRODUCTION.

Bee keeping is not an industry which brings a fortune to a few, but is one the profits of which add comfort to 700,000 homes in America. This industry, which is a pleasure and a profit to so many, is beset with difficulties. One of the greatest obstacles encountered in the successful pursuit of bee keeping is disease. There are a number of diseases which attack the honey bee. Those which cause the greatest loss attack the brood. These diseases are known to the bee keeper as American foul brood, European foul brood, and pickled brood. Considerable loss is sustained also from paralysis and dysentery. Other disorders of less importance are sometimes encountered. If the apiarist is to treat these diseases effectively, he should become as familiar as possible with their etiology. Therefore this opportunity has been chosen to discuss the causes of bee diseases, as far as they are known, and to emphasize the importance of such knowledge in the treatment.

The word " disease " is made up of two parts, " dis," referring to a negative condition, and " ease," meaning a state of rest. By combining the parts we have the very appropriate word meaning a negative state of rest. We are all familiar with health, which is the state of rest. It is the condition which we experience when all the organs of the body are, so to speak, in a state of equilibrium. Any departure from this state of health is disease. You should remember that disease is alike in nature in all the animal kingdom and differs only in kind.

To understand best the nature of disease we must study the causes of disease. A number of factors may combine and be responsible for a diseased condition. This group of factors is known as the " etiology." Etiology, then, means the causation of disease. Let us further consider the etiology of disease and use bee diseases largely as illustrations.

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[a] Read at the meeting of the National Bee-Keepers' Association, Detroit, Mich., October 14, 1908.

ETIOLOGY (CAUSE) OF DISEASES.

Every abnormal condition in the body of an animal which we know as disease has a cause which has brought about such a condition. In most of the diseases of man and the higher animals comparatively little is known of the cause. Likewise, and unfortunately, the same is true of bee diseases. Gradually but slowly new facts about all diseases are added to our knowledge, the unfortunate thing being that so many statements are reported as facts which have never been demonstrated to be true.

In the study of the etiology of a disease and in the discussion of it, it is convenient to divide the causal factors into predisposing and exciting. Under the predisposing causes which may be considered as factors in bee diseases we have age, sex, race, heredity, climate, and preexisting disease. Under the exciting causes we may consider food and micro-organisms.

To illustrate, let us consider the different factors just mentioned.

PREDISPOSING CAUSES.

Age.

In our experience with human diseases we have learned to expect scarlet fever, measles, mumps, and whooping cough more often in children than in adults; typhoid fever and appendicitis in young adults; and cancer in those more advanced in life. In bee diseases we expect European foul brood to attack larvæ that are younger than those which suffer from American foul brood. We expect the so-called "pickled brood" to die just before or after capping, while paralysis is, as far as we know, a disease of adult life.

Sex.

Of some importance in the etiology of human diseases is the factor sex. Inflammatory rheumatism, gout, and diabetes, for example, occur more frequently in men, while goiter and hysteria are more frequent in women. In bee diseases we expect in American foul brood to find the worker larvæ more often attacked than the drone, while in European foul brood this difference, if it exists, does so only to a slight degree.

Heredity.

You are all familiar with the fact that heredity is considered as an important predisposing factor in tuberculosis, cancer, gout, insanity, etc. It is interesting that in the so-called "pickled brood" there is some evidence which indicates that heredity plays an important rôle.

Race.

Racial immunity is a rather interesting factor in the study of human and animal diseases. The negro, for example, seems to possess considerable immunity in gout and diabetes compared with the white race. Sheep ordinarily are very susceptible to anthrax, but there is an Algerian race of sheep which is immune to this disease. Some bee keepers believe that race is an important factor in bee diseases, but comparatively little is definitely known on this phase of the etiology.

Climate.

That human diseases are more frequent in some climates than in others is a fact familiar to us all; that climatic conditions play a part in bee diseases seems to be quite probable.

Preexisting Disease.

Preexisting disease has very little, if anything, to do with bee diseases. By preexisting disease we mean that when an individual passes through an attack of a disease the disease predisposes that individual to other diseases. This is illustrated in various human and animal diseases. In bee diseases we do not know whether any larva or pupa ever recovers sufficiently from an attack of disease to continue its development and emerge as an adult bee. Many bee keepers think that adult bees in American foul-brood colonies are less active than in normal colonies. Whether or not they suffer from disease we do not know. It is possible, but not so probable, that they have suffered a light attack of disease while in the developmental stage and emerged as adult bees with weakened organs which do not perform a normal function. If this were true, it would illustrate the importance of preexisting disease as a predisposing factor in etiology.

Having thus briefly considered some of the more important predisposing causes which enter into the etiology of bee diseases, let us consider two of the more important exciting causes—food and micro-organisms.

EXCITING CAUSES.

Food.

The character of food is believed by many bee keepers to be an exciting factor in dysentery. Should the food contain poisons, grave results might follow. Some attribute paralysis to the character of the food, but this is far from a demonstrated fact.

Micro-organisms.

By micro-organisms we mean those living plants and animals which are very small and must be magnified greatly before they can be seen. Those which are to receive our attention are bacteria, protozoa, and fungi.

Bacteria.—We have now come to the consideration of that factor in the etiology of bee diseases which is most important and with which we would have the bee keepers become familiar. The annual loss sustained by the bee keepers of this country due to the one cause, bacteria, is to be reckoned in millions. It is unfortunate that it is necessary to use the word bacteria, because too many at once think that they are not able to understand anything about bacteria. This is a mistaken idea. It is not difficult to understand the facts about them which are most important in the treatment of disease. It might be well to review here some of the things known concerning their life history.

Nearly two years ago the writer had the honor of reading a paper at a meeting of bee inspectors held at San Antonio, Tex., upon the subject of the bacteriology of bee diseases. This paper appears in Bulletin No. 70 of the Bureau of Entomology of the United States Department of Agriculture, page 10. In it are discussed briefly the nature of bacteria, their distribution, the methods of studying them, and the results of their activity. It is stated that bacteria—often called germs, microbes, and parasites—are very small plants; so small, indeed, that 12,000 placed end to end measure but 1 inch. They increase in number with marvelous rapidity. Under favorable conditions each bacterium in twenty minutes becomes two. At this rate countless millions are formed in twenty-four hours. As the soil becomes exhausted in which they are growing many species form spores which are in a way comparable to the seeds of higher plants. These spores are very difficult to destroy by heat and other disinfectants. It is well to remember, concerning the distribution of bacteria, that they are found in very large numbers everywhere about us, but that most of them are as harmless as the vegetables we eat. But should there be introduced into an apiary, for example, the species of bacteria which causes American foul brood, then the brood becomes exposed to the disease and will probably contract it.

The study of bacteria must be carried on for the most part in the laboratory. By the use of the microscope we are able to tell the genus (e. g., *Bacillus*) to which an organism belongs, and by specially prepared media, or soils, we are able to determine the species to which it belongs (e. g., *alvei*).

Having determined these things about bacteria, we are interested in finding out what they are capable of doing. We learn that some do good, as, for example, in bringing to decay the remains of dead animals and plants, while other species do harm by their ability to produce disease or death in the animals in which they are able to gain entrance. The disease American foul brood, which causes the greatest loss to the bee-keeping industry, has been demonstrated to be caused by bacteria. Above all, you should understand that the death of the brood is due to one species of bacteria growing in the larvæ.

Protozoa.—In contrast to bacteria, the protozoa belong to the animal kingdom. They are very small unicellular animals. Many species are harmless, as are many species of bacteria, while some species have the power to produce disease. They produce disease and death in a manner very similar to bacteria; that is, by growing in the body of a living animal. As far as we know, none of the bee diseases is due to protozoa. One investigator described what he thought was a protozoon and named it *Spirochæta apis.* It was shown that he made an error in his observations. Therefore there is no *Spirochæta apis* and no protozoon, as far as we know, which is pathogenic to bees.

Fungi.—The term "fungi" is a rather broad one, but in the diseases of animals we usually refer, in speaking of fungi, to those forms of plant life which are higher than bacteria. They are usually made up of branching mycelial threads, and have a variety of methods for producing spores. One writer described one species, *Aspergillus pollini*, which he was supposed to have proved to be the cause of pickled brood, but he had not done so.

To the above groups belong the known exciting causes. There are also unknown exciting causes. When the unknown causes become known they may be found to belong to the groups mentioned above.

There is a very important classification of diseases into those which are infectious and those which are noninfectious. From what has been said, this classification becomes clear to us. An infectious bee disease is one which may be transmitted from one colony to another through the natural processes in the apiary. American foul brood and European foul brood are examples of this class of disease. What is transmitted in an infectious disease? It is the exciting cause of that disease. In American foul brood it is one species of bacteria, *Bacillus larvæ.* In European foul brood we do not know what is transmitted. Since we do not know the exciting cause it must be classed under the unknown exciting causes. When the cause is determined it will probably be found to belong to one of the three groups of micro-organisms mentioned under the known causes. A noninfectious disease is one which is not transmitted from one colony to another. The so-called "pickled brood" and paralysis, as far as we know, illustrate this class of diseases.

This brief discussion of the etiology of disease is given in order that you may get a clearer idea of the nature of disease and what is meant by etiology. We shall now consider the treatment of disease and illustrate with bee diseases.

TREATMENT OF DISEASE.

The ultimate object in the investigation of diseases is the successful treatment of them. Before a disease can be treated rationally the diagnosis must be made; in other words, it must be determined what disease is present. If, for example, the so-called "pickled brood" is present in an apiary, the treatment will be quite different from what it would be if American foul brood or European foul brood were present; and if no disease is present, as sometimes happens, and the bee keeper suspects a disease, it is important that a positive diagnosis be made of this condition.

There is no method by which bee disease can be so positively diagnosed as by the finding of the exciting cause in the affected and dead bees. This fact is made use of in diagnosing samples of brood sent to the laboratory and illustrates one important advantage in knowing the etiology of disease. If we are to devise methods for treatment it is important that we should know where the exciting cause exists, under what conditions it grows, how it is carried from one place to another, and how it may be destroyed. These facts are determined by a study of the etiology of the disease, and it is upon such facts that we should base the treatment.

Those who are familiar with bee diseases are also familiar with the different methods of treatment. It is not the purpose of the writer to discuss any of the classical methods, but to suggest a few of the principles upon which such methods must be based if they are to be most effective. Treatment is both preventive and curative.

PREVENTIVE TREATMENT.

Too many believe that the treatment of bee diseases consists in the control or eradication of a disease after it is found in the apiary. This is only the minor part of treatment—the curative. The treatment which is of major importance is the preventive treatment. Prevention is much easier than cure. To prevent disease in the apiary is to keep it out. To keep it out is to keep out the exciting cause. In order to keep out the exciting cause, it is desirable to know its distribution or where it is found. In American foul brood the exciting cause, *Bacillus larvæ*, is found in immense numbers in the bodies of diseased and dead larvæ. These dead larvæ, for the most part, are allowed by the bees to remain in the brood cell as a scale. The honey also has been demonstrated to contain the bacteria which produce this disease. The pollen may be contaminated with the spores of this disease-producing organism. The combs from an apiary affected with American foul brood are a fruitful source of infection. The inside of the hives which have contained colonies suffering with American foul brood may be contaminated with the germs which cause the disease. Honey extractors, honey tanks, and wax extractors which have been used in infected apiaries are also a fruitful source of infection. Therefore if you are to keep the disease-producing bacteria out of your apiary, and thereby keep out disease, you must not feed honey unless you are positive that it did not come from an infected apiary or that it has been thoroughly boiled. Neither must you use old combs unless you are positive that they have not been in an infected apiary. Use no bee supplies from an infected apiary unless they are thoroughly disinfected.

These things being true of the infectious disease American foul brood, of which we know the cause, until the cause of any other infectious disease can be determined we can do no better than to suggest the use of the same principles in the treatment of such a disease as must be used in the successful treatment of American foul brood.

CURATIVE TREATMENT.

In the curative treatment, considering the colony as a unit, use is made of two widely different principles—the removal of the disease-producing material, thereby removing the germs, and the use of drugs.

In separating the disease-producing germs from the colony, all the combs are removed. This removes the principal sources from which the brood is infected—foul-brood larvæ and honey. It is always safer to allow the bees to go into a new hive or a hive which has been thoroughly disinfected. The greatest care should be exercised in protecting all infectious material which has been removed, that it may not be robbed by the bees.

The principle involved in the treatment by drugs is that of an antiseptic. The theory is that a small amount of some drug—like beta naphthol, salicylic acid, carbolic acid, eucalyptus, formic acid, etc.—is sufficient, when taken with the larval food, to inhibit the growth of the pathogenic bacteria.

Having thus in a general way considered the subject of the etiology of disease and the treatment in accordance with such knowledge, let us consider the different diseases separately.

AMERICAN FOUL BROOD.

That *Bacillus larvæ* is the cause of American foul brood has been demonstrated conclusively. It is a species of bacteria which when it is introduced into the healthy larvæ multiplies rapidly and causes the death of a large amount of the brood. When the larva dies the body decomposes and the remains dry down to a tongue-like scale on the lower side wall of the cell. In this scale are millions of spores which are able to produce disease in other larvæ should they be fed to them.

Just how the bacteria are carried from a dead larva to a healthy one we do not know. It is not uncommon, in examining the brood, to find only a portion of a larva in a cell, the bees having removed a part of it. When the body wall of a larva is broken in examining for foul brood, bees readily suck up the contents which flow out. This is true when the larva which is punctured is healthy, or when it is sick with disease, or after it has been dead a few days. The larvæ at these stages of the disease contain a very large number of the disease-producing bacteria. These observations would indicate that in this way, in part at least, the infectious material might be carried to healthy larvæ. Actual contact of the appendages of the bee with the foul-brood material, and the subsequent contact of the same appendages with the food of the larvæ, may be a method by which the disease-producing bacteria are spread. We do know that in foul brood it is possible to obtain *Bacillus larvæ* from the honey, and we do know that when bees are fed the spores of *Bacillus larvæ* in honey American foul brood will appear in the apiary.

The spores of this bacillus are very resistant to heat and other disinfectants. They resist the boiling temperature of water for fifteen minutes. In 5 per cent carbolic acid they were not killed in two months' time. This was demonstrated by obtaining growth in cultures after the spores had remained in this disinfectant for that length of time. Likewise it has been demonstrated that the spores of *Bacillus larvæ*, when taken from the scales of American foul brood, resist the action of mercuric chloride (corrosive sublimate), 1:1,000 aqueous solution, for two months. Having such facts before us, we can better judge the methods for treatment.

In treating this disease we must bear in mind the preventive and curative measures. In the preventive treatment many of the conditions you can control; others may be difficult. You can at least be sure that you import no bees or used supplies which might have been in an infected apiary. Use no old combs and feed no honey of which you do not know the history. In this way the bacillus which causes the disease in a large measure can be kept out of the apiary. There are conditions which are difficult to control. Should a near-by apiary be diseased and some of the colonies become weak or die out, it might be difficult for you, in a dearth of nectar, to keep your bees from robbing the diseased apiary and in this way bringing these disease-producing germs to your healthy colonies.

Some preliminary experiments have been made, but the results do not indicate that drugs, in the treatment of this disease, have the value advocated by some English writers.

EUROPEAN FOUL BROOD.

European foul brood is another infectious bee disease. It attacks the brood at an earlier period in the growth of the larvæ, as a rule, than American foul brood. The cause of this disease is not definitely known. From brood dead of this disease Cheshire and Cheyne isolated *Bacillus alvei*. From their work it was long supposed that *Bacillus alvei* was the cause of the disease, but later investigations make the value of their work doubtful.

A number of organisms have been found in the larvæ dead from this disease and some of them have been described. One species has been encountered in our investigations of the disease which is of special interest. The individuals of this species are quite small, apparently non-spore-producing, and have so far failed to grow when sown on our artificial media. Until we know more about this species it will be referred to as *Bacillus* "*Y*." Since the cause is not positively known, the amount of heat and chemical disinfectants to destroy the virus has not been demonstrated. If, later, *Bacillus* "*Y*" is demonstrated to be the cause, we shall expect that very much less heat will be sufficient to kill it than is necessary to kill *Bacillus larvæ*, the cause of American foul brood. Likewise we shall expect that chemical disinfectants will be much more readily effective. Until we know more about the etiology of European foul brood we can do no better than to suggest the application of the same principles which are found advisable in American foul brood.

SO-CALLED "PICKLED BROOD."

We refer to this disorder of the brood as the "so-called pickled brood" and not pickled brood, because the condition which William R. Howard, of Fort Worth, Tex., described is not what the bee keepers know as pickled brood. The exciting cause of this disease is not known. The larvæ die at that age just preceding or just after capping. Some bee keepers have a theory that heredity plays a very important part as a predisposing cause. As far as is known the disease does not seem to be infectious.

This disease is treated by some bee keepers by requeening, on the assumption that heredity is the important factor in the production of the disease. If more were known concerning the etiology, the treatment might be materially changed.

PARALYSIS.

Paralysis is a disease of the adult bee. The cause of this malady is not known. It does not seem to be infectious, although in some apiaries a large number of colonies may be affected at the same time. Some have advanced the theory that the character of the food is the exciting cause.

Since we know nothing positively about the cause, we can suggest very little in the way of treatment. The removal of the stores from the hive would tend to remedy the defect if the character of the food be an important factor in the etiology.

SUMMARY AND CONCLUSIONS.

We have now briefly considered the nature and the etiology of bee diseases and have suggested some of the principles upon which the methods of treatment must depend if such treatment is to be most efficient. If we review what we have just said concerning the etiology and treatment of the different diseases, we observe the following facts:

There is but one disease, American foul brood, of which we know absolutely the exciting cause. The cause is a species of bacteria, but there are many things concerning the nature, the distribution, and the activity of which we do not know. The facts which have been determined enable us to suggest some of the principles upon which the treatment must be based. Just so rapidly as our knowledge of the etiology of this disease increases, so rapidly will we be able to suggest principles for the improvement of the methods of treatment.

In European foul brood we only know positively that the disease is infectious, and we can do no better than to use the principles gained by the study of American foul brood. As our knowledge of the etiology of this disease increases, the methods of treatment will be altered.

In the so-called "pickled brood" we do not seem to have an infectious disease. Nothing is positively known of the etiology except that the larvæ die at approximately the same age in all cases, which is about the time of capping. The treatment that is used by some is based upon the principle that heredity is an important factor, and therefore requeening is resorted to.

In the disease of adult bees known as "paralysis," practically nothing is known and practically no treatment is known to be effective.

It will be noted that in every case the treatment of bee diseases is based upon the knowledge of the etiology. There are many things of very great importance in the etiology which are yet to be determined, but there are many things which are known that, if applied by the bee keeper, will prove to be of great value to him financially. It is to be hoped, then, that the bee keeper will make himself as familiar as possible with the nature of the etiology of bee diseases, since it is clear that the better the cause is known the better will be the treatment. From this discussion one conclusion can be drawn—that in the knowledge of the etiology of bee diseases lies the hope of their control.

O

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 75, Part V.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

A BRIEF SURVEY OF HAWAIIAN BEE KEEPING.

BY

E. F. PHILLIPS, Ph. D.,
In Charge of Apiculture.

Issued January 19, 1909.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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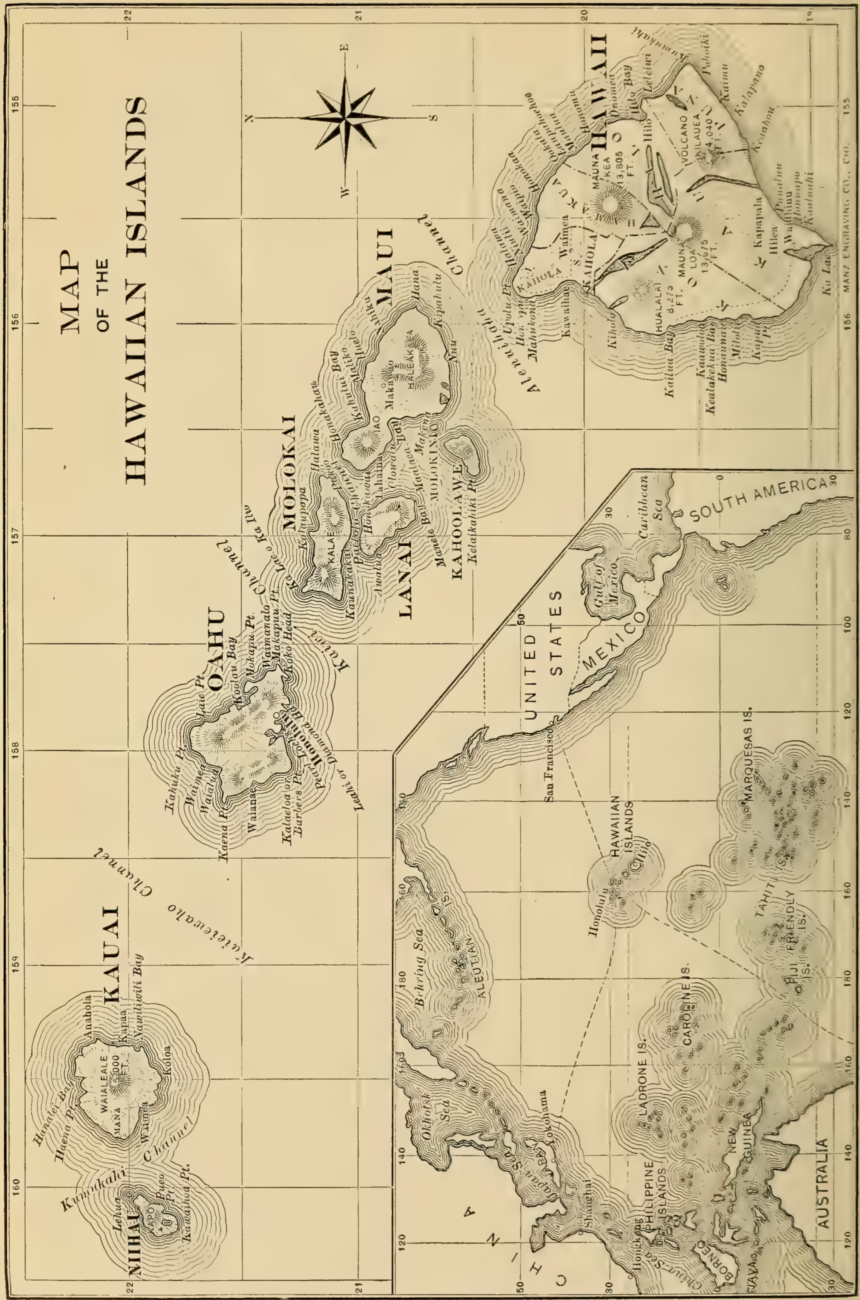
MAP OF THE HAWAIIAN ISLANDS
KAUAI
NIIHAU
OAHU
MOLOKAI
LANAI
MAUI
KAHOOLAWE
HAWAII
Kauai Channel
Kaieiewaho Channel
Kaiwi Channel
Pailolo Channel
Alenuihaha Channel
Honolulu
Lahaina
Hilo
Waimea
Koloa
Anahola
Hanalei Bay
Nawiliwili Bay
Waialeale 5,000 Ft.
Haleakala
Mauna Kea 13,805 Ft.
Mauna Loa 13,675 Ft.
Hualalai 8,275 Ft.
Volcano Kilauea 4,040 Ft.
Kailua Bay
Kealakekua Bay
Diamond Head
Koko Head
Pearl Lochs
Kalaupapa
Ka Lae
Molokini
UNITED STATES
MEXICO
SOUTH AMERICA
San Francisco
Gulf of Mexico
Caribbean Sea
HAWAIIAN ISLANDS
ALEUTIAN IS.
Behring Sea
Okhotsk Sea
JAPAN
Yokohama
Shanghai
Hongkong
CHINA
PHILIPPINE ISLANDS
LADRONE IS.
CAROLINE IS.
MARQUESAS IS.
TAHITI IS.
FIJI IS.
FRIENDLY IS.
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MISCELLANEOUS PAPERS ON APICULTURE.

A BRIEF SURVEY OF HAWAIIAN BEE KEEPING.

By E. F. PHILLIPS, Ph. D.,

In charge of Apiculture.

INTRODUCTION.

Bee keeping on the Hawaiian Islands is one of the minor industries which is being conducted with profit. As in all other places, this business can never, from its very nature, become a leading industry, but there is reason to believe that there is yet room for considerable expansion. The modified methods made necessary by a tropical climate and other conditions of a local character present some new phases of the keeping of bees, and in view of the fact that these modifications will be of interest to bee keepers on the mainland, as well as to those in Hawaii, it seems desirable to put on record a brief account of what the author was able to observe personally and to learn from others in the four weeks spent on the islands in making an apicultural survey.

The author would express his thanks to the bee keepers of the islands for the cordial way in which they anticipated his every desire in planning the trips of investigation. He would also mention the particular assistance of Mr. D. L. Van Dine, entomologist of the Hawaii Agricultural Experiment Station, who accompanied him on all his trips, and from whom much of the information in this paper was gathered.

PUBLICATIONS ON HAWAIIAN BEE KEEPING.

Different phases of Hawaiian bee keeping are discussed in other publications, a list of which is appended.[a] The bee keepers of the islands have been extremely fortunate in enlisting the interest of the Hawaii Agricultural Experiment Station. Mr. D. L. Van Dine, the entomologist of the station, has been very active in rendering valuable assistance to the bee-keeping industry by his investigations, and Miss Alice R. Thompson, the acting chemist, has done good work in chemical analysis of honeys.

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[a] Reports of the Royal Hawaiian Agricultural Society (1851–1856).

A Brief History of the Hawaiian People, by W. D. Alexander, 1899, p. 286.

Report of the Entomologist, by D. L. Van Dine, in Report on Agricultural Investigations in Hawaii, 1905, by Jared G. Smith. Bulletin 170, Office of Experiment Stations, U. S. Dept. of Agriculture, 1906.

Report of the Entomologist, by D. L. Van Dine, in the Annual Report of the Hawaii Agricultural Experiment Station for 1907, 1908.

Introduction of Honey-Producing Plants, by D. L. Van Dine; Hawaiian Forester and Agriculturist, Vol. V, pp. 9–13.

Hawaiian Honeys, by D. L. Van Dine and Alice R. Thompson. Bulletin 17, Hawaii Agricultural Experiment Station, 1908.

Chemical Analysis and Composition of American Honeys, by C. A. Browne, including a Microscopical Study of Honey Pollen, by W. J. Young. Bulletin No. 110, Bureau of Chemistry, U. S. Dept. of Agriculture, 1908.

BEE-KEEPERS' ASSOCIATION.

The bee keepers of Hawaii are organized into an active and efficient association, which has been in existence about two years. By united effort this organization has accomplished much that is of great value to the industry. When the question of marketing their honey under the regulations of the food and drugs act of 1906 arose they sent a representative to Washington to present their case. In this and many other ways the bee men have shown themselves to be alert and progressive in looking after their best interests.

METHODS OF MANAGEMENT.

At the present time bee keeping is largely in the hands of four corporations, they owning and operating at least four-fifths of all the bees on the islands. These companies are all managed by American citizens, but there are a number of smaller apiaries, some of which are owned by Japanese. The last-named apiaries are usually not so well kept nor are they so productive. The total number of colonies at present is probably about 20,000, and the annual output of honey, which is mostly shipped to the mainland or to Europe, is probably about 600 tons.[a] The keeping of bees by corporations, as opposed to individual ownership, is something which is rarely observed elsewhere. As they are located a considerable distance from the market and as the expense of supplies and shipping is high, it has seemed desirable to the bee keepers to organize companies so that they may make large shipments. There is also on the Hawaiian Islands a tendency, to a marked degree, to incorporate all industries, and doubtless the prevalence of this method of conducting business has induced the bee keepers to adopt it also. With this system it is possible for one skilled manager to oversee the manipulation of several thousand colonies, the actual manipulation being done in most cases by the Japanese helpers; in this way the cost of maintenance of the apiaries is reduced very considerably. Since the price obtained for Hawaiian honey is still rather low, it is of course necessary to reduce expense in every way possible.

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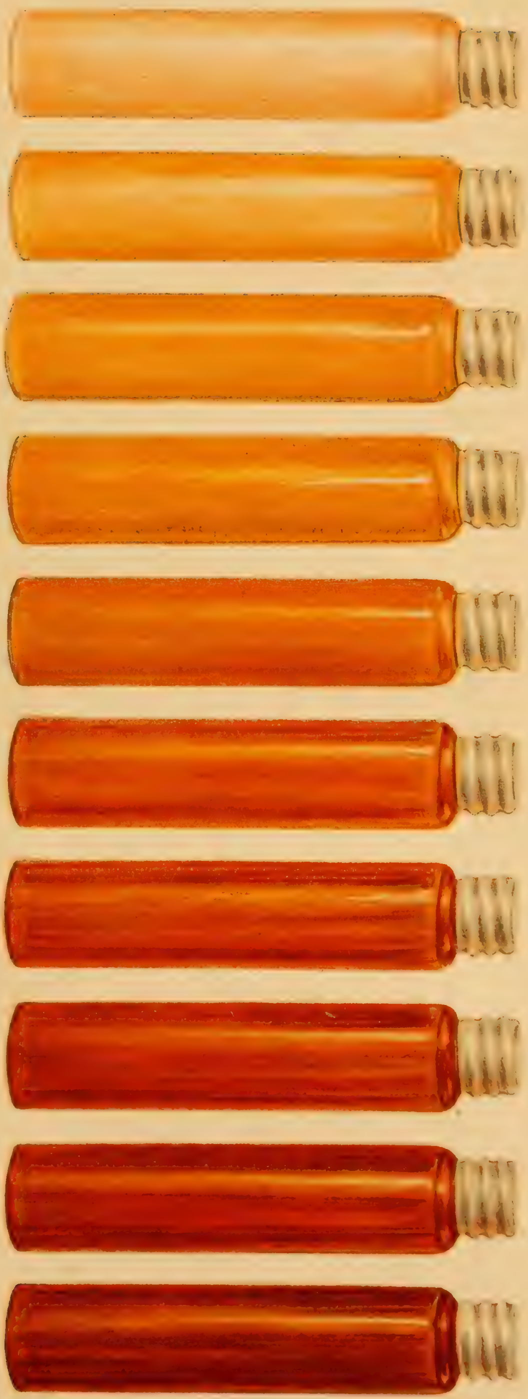
[a] The crop for 1908 will probably amount to nearly 1,000 tons, according to a recent report from the entomologist.

PLATE VI.



BLENDS OF ALGARROBA HONEY AND HONEYDEW FROM THE HAWAIIAN AGRICULTURAL EXPERIMENT STATION.

[PLATE I, BUL. 110, BUREAU OF CHEMISTRY.]

A. HOEN & CO. BALTIMORE.

"BEE RIGHTS."

The buying of "bee rights," as it is practiced in Hawaii, is something practically unheard of elsewhere, and would certainly appear to a mainland bee keeper as a new and strange procedure. The nearest approach to it is the renting of locations for outyards, which can not usually insure no competition. This practice would not be possible were it not for the fact that most of the available agricultural land on the islands is held in large tracts, mostly as sugar-cane plantations and ranches. Arrangements are made with the manager of a plantation for locations for apiaries, and the bee keeper agrees to pay a certain amount for the use of the land and for the honey removed from these apiaries. Frequently this is in the form of an agreement to pay a certain sum for each ton of honey removed from the plantation, but at times it is a fixed sum for the year, the bee keeper assuming what small risk there is of not getting a crop. The plantation management in turn agrees to allow no other bee keepers to keep bees in its territory. There are frequently small holdings within the boundaries of the plantation over which the plantation company has no control, and some other bee keeper may lease these with the idea of allowing his bees to range over the entire plantation. If, for example, he puts 200 colonies on such a holding, the immediate placing of say 500 colonies just across the line has a discouraging effect on this poaching and it can end in only one way, since the bee keeper who has a right there has the advantage. The same thing happens when an outside bee keeper gets too close to the boundary line.

Naturally, when land is divided into smaller holdings, as is the case almost everywhere on the mainland, such an arrangement is not possible and a bee keeper must run the risk of competition. There is no way of telling what amount of honey is taken from any given area when the tracts are small. The moral right of priority claim, which so many bee keepers advocate, has small place in the manipulations of territory in Hawaii, where the bee-keeping companies pay for what they get and insist on getting it. One of the large companies gains its exclusive right by reason of the fact that it owns and leases a tract of over 100,000 acres for ranch purposes.

EXTENT OF THE INDUSTRY.

At the present time there are on the islands probably about 20,000 colonies of bees, most of which are, as above stated, owned by four companies. From the custom-house statistics it is shown that the annual shipments of honey amount to about 1,000 tons. The island of Kauai now supports about 3,000 colonies, and, after traveling over almost the entire cultivated portion of the island, the author is of the opinion that the island is just about half stocked. The island of Oahu seems to be well covered from an apicultural standpoint. Molokai is not a cane-producing island, but the algarroba forest is nearly stocked, and the only place for heavy expansion seems to be in the mountains, where several forest trees are nectar bearing. The island of Maui could not be examined as carefully as the others on account of inclement weather, but from reports received it is obviously not stocked to the extent that it should be. The island of Hawaii, the largest of the group, is relatively the least developed of any of the islands. There are only a few apiaries on this area, which is almost equal in extent to Connecticut, and there are great possibilities. On the south coast there are vast areas of cane, and the same is true of the Hamakua coast on the north. The Kona coast would probably support some bees in the coffee plantations. One such apiary was seen by the author (Pl. VII, fig. 2). On the interior of the island there are vast areas which are entirely undeveloped from an apicultural standpoint, and the island can doubtless support thousands of colonies of bees at a profit.

The total area now actually stocked with apiaries would not nearly equal in size one-half the State of Rhode Island, while the honey crop is probably 20 times as great as in that State. According to the Census Report for Rhode Island it would be 40 times as great, but we can not use this figure on account of its obvious unreliability. This comparison will show the honey-producing capabilities of the islands as compared with our more northern countries, and will also show how thoroughly the areas are stocked where the industry has been taken up. A small part of Oahu is doubtless overstocked, due to crowding into a given area by competitive companies. There was no evidence of such overstocking elsewhere.

Overstocking an area with bees is a subject much discussed among bee men, and the situation in Hawaii illustrates very beautifully the fact that a theoretical discussion of how many colonies may be kept in one place is of no value whatever. Each location must be judged on its own merits, and a given area which will support only 20 colonies in one region may support 1,000 elsewhere. It is also obvious that seasons vary to a marked degree. In many parts of the mainland it is deemed advisable to keep not more than 100 colonies in one apiary and to allow each apiary a radius of 1½ to 3 miles. On the basis of these figures, from 50 to 200 acres are necessary to support a single colony of bees. Without discussing the merits of these figures, it is enough to say that this is the common mainland practice, particularly in the more densely populated areas. In contrast to this, an examination of the methods in Hawaii is extremely significant. One area of cane on the island of Oahu contains a little over 20,000 acres. As will

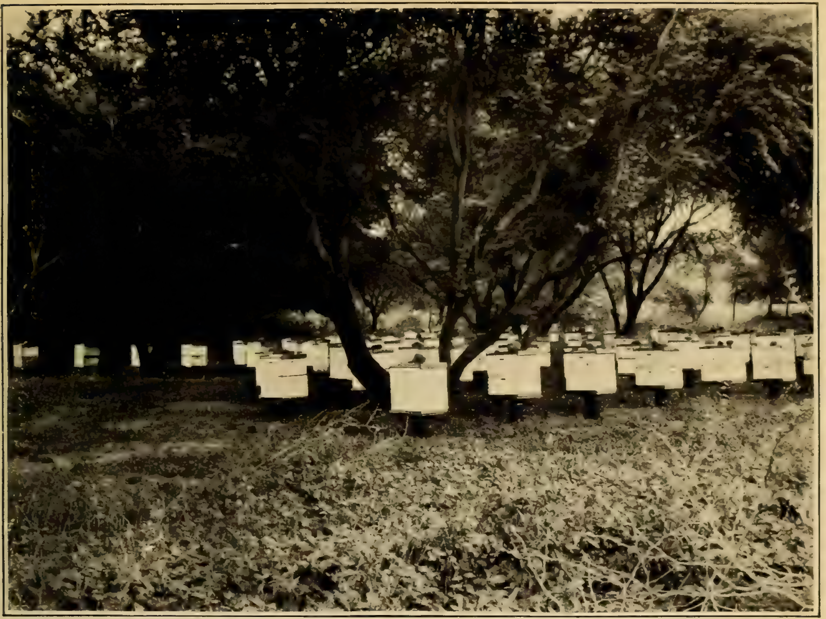


FIG. 1.—A TYPICAL HAWAIIAN APIARY, THE HIVES ON STANDS TO PREVENT ANT ATTACKS. (ORIGINAL.)

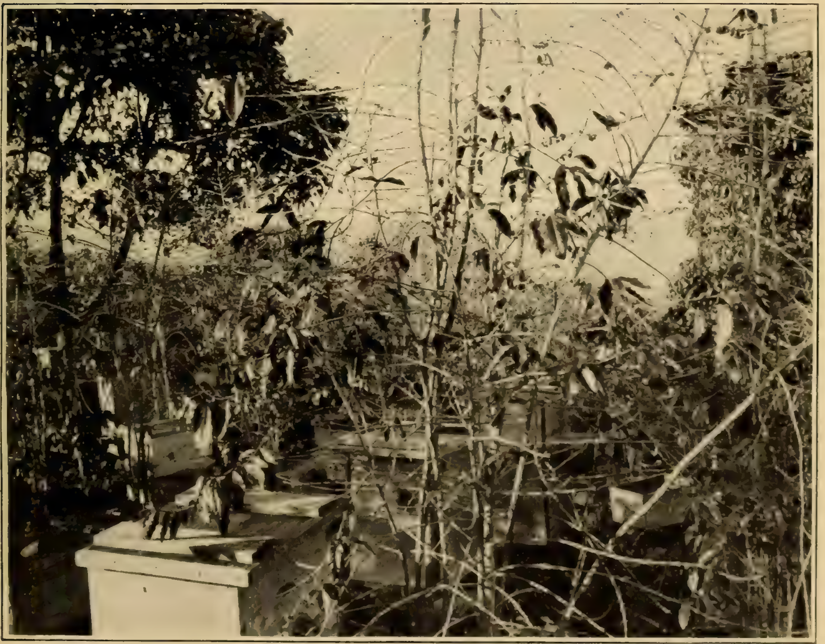


FIG. 2.—AN APIARY IN A COFFEE PLANTATION. (ORIGINAL.)

be discussed later, this is not all equally productive from a bee-keeping standpoint. Near this is some algarroba forest, but not enough to influence the crop very much. This area supports nearly 5,000 colonies, some of which yield exceptionally large crops. In certain parts of this area competition is too strong to yield proper results, but some apiaries yield over 200 pounds to the colony. In some other cane areas this record can be almost equaled. Algarroba will not produce so much per acre, but this is partly due to the fact that it blooms for less than six months, while cane fields furnish honeydew every day in the year. One strip of algarroba forest on Molokai supports nearly 2,000 colonies. It will not average more than one-half mile in width, and about 30 miles of it is used for bees.

SOURCES OF HONEY.

FLORAL HONEY.

The amount of floral honey produced on the islands annually is about 200 tons. Formerly the only source of honey on the islands which was widely enough distributed to make bee keeping commercially important was algarroba, native "keawe." (Pl. VIII, fig. 1.) This tree was introduced into the islands by Father Bachelot, founder of the Roman Catholic mission, in 1837, and the original tree still stands on Fort street, in Honolulu. It has been carried to all the islands and is one of the most valuable plants ever brought into the group. It furnishes not only an excellent honey, but the pods afford excellent fodder and the wood is the main source of fuel.

The honey from algarroba is "water white" in color and granulates very soon after it is stored by the bees in spite of the warm climate of the islands. This characteristic makes frequent extractions necessary to prevent the combs from being clogged. In regions where algarroba is practically the only source of honey, at the close of the flow an amount of honey sufficient to keep up the colony until the next flow is left in the hive. This, of course, soon granulates. When the honey flow diminishes, the brood chamber is reduced and considerable honey is stored in the space formerly occupied by brood. When the next flow comes on, a good deal of this granulated honey remains in the combs, and since this can not be extracted, these combs are removed and replaced either by empty combs or by foundation, to give the queen more room. These combs containing granulated honey are then placed in huge solar extractors, the largest that the author had ever seen. With 200 or more colonies in an apiary, there is often need for a solar extractor which will hold several hundred combs at a time, and practically every apiary visited by the author had such a piece of apparatus as part of the equipment. The sun's heat liquefies the honey and melts most of the wax, and the wax from the "slumgum" is then extracted by the usual methods. The honey from these solar extractors is not darkened, as one would expect.

The algarroba tree (*Prosopis juliflora*) is either the same species as or very closely related to the mesquite of the southwest. On the islands it grows to the size of a tree, as is also the case in Mexico. In Texas it is generally very much smaller. In 1908 the tree came into bloom about the 1st of March, the time varying considerably in different localities on the islands. It usually blooms until August, and this very long blooming period adds greatly to its value to the bee keepers.

The following list of honey plants, other than algarroba, is furnished by Mr. D. L. Van Dine, entomologist of the Hawaii Agricultural Experiment Station. Mr. Van Dine has studied the honey sources of the islands very thoroughly. Many of these plants were pointed out to the writer while he was on the islands.

FOREST TREES.

Texas mesquite (*Prosopis glandulosa*). Growing in dooryard of Mr. C. C. Conradt, Pukoo, island of Molokai. Seeds under propagation at Hawaii Agricultural Experiment Station. Introduced by Mr. Conradt from Texas several years ago.

Ohia lehua (*Metrosideros polymorpha*). Produces a particularly high grade of honey. Locations for apiaries as a rule somewhat inaccessible. One location on the island of Molokai is within the ohia lehua belt.

Various species of Acacia (black wattle, koa, etc.). Mountainous districts.

Various species of Eucalyptus. Mountainous districts.

Wiliwili (*Erythrina monosperma*). In gulches on Molokai and Oahu.

Rose-apple (*Eugenia jambos*).

Mamani (*Sophora chrysophylla*). Found in higher forest belts.

Catalpa (*Catalpa speciosa* and *C. bignonioides*). Introduced by Mr. Jared G. Smith, April, 1902, from the Missouri Botanical Gardens. The seeds were distributed to L. von Tempsky, Makawao, and H. P. Baldwin, Puunene, on Maui; to S. M. Damon, Moanalua Gardens, on Oahu; to Francis Gay, Makaweli, on Kauai; and to Louisson Brothers and Albert Horner, Hamakua, and B. B. Bond, Kohala, on Hawaii. The seeds were sent to the above-named parties under date of April 10, 1902. No reports are on file at this station as to the results of this introduction.

Logwood (*Hæmatoxylon campechianum*). Found in dooryards. Two trees are growing in the grounds of Oahu College and one in the grounds of Lunalilo Home, Honolulu. Seeds under propagation at Hawaii Agricultural Experiment Station. The honey produced by bees from this tree is reported to be the finest table honey in the world. The propagation and distribution of the logwood throughout the Territory would be of great value to bee keepers. The wood furnishes the logwood dye of commerce.

The black mangrove of Florida. Introduced by Mr. Jared G. Smith from southern Florida, for the purpose of preventing the mud flats from washing, along the coast of Molokai near Kaunakakai. The introduction was made several years ago and the trees are now well established at the above-mentioned place. The tree is a valuable honey plant. The station is now trying to secure the Philippine mangrove, a tree suitable for similar locations but possessing greater value as a timber tree.

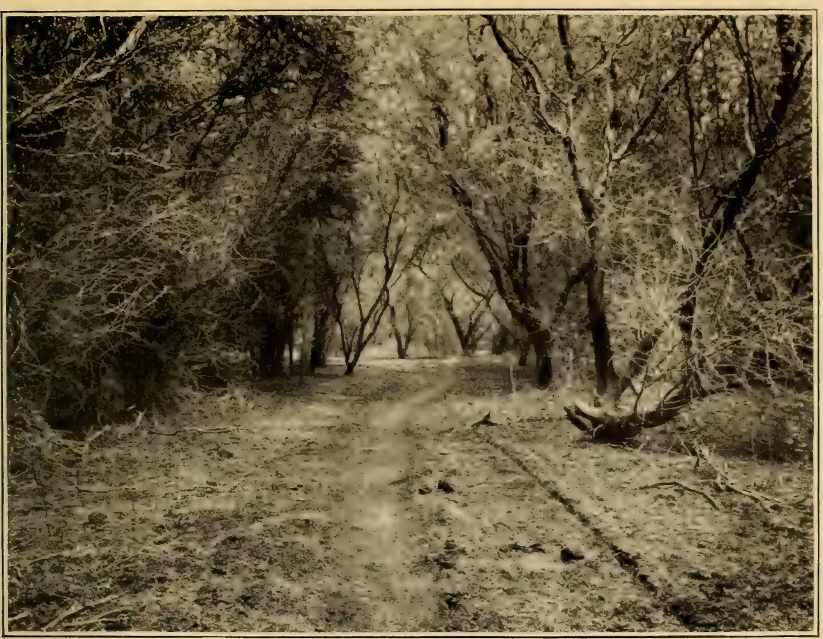


FIG. 1.—PART OF AN ALGARROBA FOREST. (ORIGINAL.)

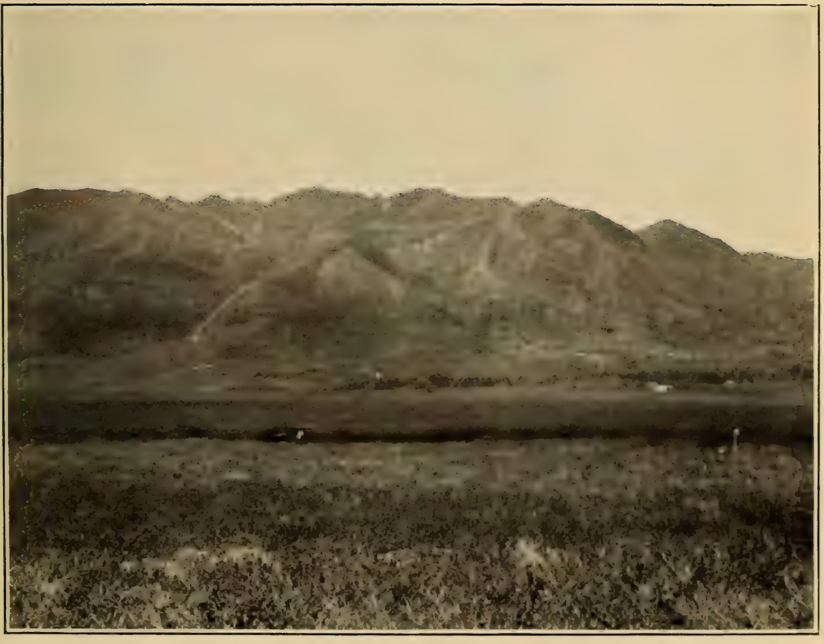


FIG. 2.—A LANTANA JUNGLE. (ORIGINAL.)

FRUIT TREES.

Various species of Citrus (orange, lemon, lime, etc.).

Avocado (*Persea gratissima*).

Banana (*Musa* spp.).

Guava (*Psidium* spp.).

Loquat (*Eriobotrya japonica*).

Tamarind (*Tamarindus indica*).

PASTURE PLANTS.

California burr-clover (*Medicago denticulata*). Introduced on Maui in 1882 by Mr. C. R. Blacow. Now found generally on the ranches of the islands

Carpet grass (*Lippia repens*). Growing on grounds of Hawaii Agricultural Experiment Station.

Alfilaria or filaree (*Erodium circutarium* and *E. moschatum*). Seeds introduced in California hay. Established on upland pastures on Hawaii and Molokai.

White clover (*Trifolium repens*). Found on Haleakala and Makawao pastures, Maui.

CROP PLANTS.

Sisal (*Agave sisalana*).

Various species of cucurbits (melons, squashes, pumpkins, cucumbers, etc.).

FORAGE PLANTS.

Alfalfa, several varieties.

Lupins, blue and yellow. Occasionally used as green manure plants on sugar plantations.

Tangier pea (*Lathyrus tingitanus*). Growing at Haiku, Maui.

Sanfoin (*Onobrychis sativa*). A forage plant introduced by Mr. Jared G. Smith in 1904. Seed distributed to ranches.

ORNAMENTAL PLANTS.

Palms, particularly the royal and cocoanut.

Poppy, a horticultural form of *Romneya coulteri*, found in gardens in Honolulu.

Chinese ink-berry (*Cestrum diurnum*).

Thevitia nercifolia.

Vines (*Ipomœa* supp.).

WEEDS.

Lantana, two species. (Plate VIII, fig. 2.)

California sages (*Artemesia*). Introduced by Hawaiian Bee Keepers' Association in 1907. Not as yet established. Suitable for waste, arid lands. The most important honey plant in California. Valuable as a forage plant.

Ilima (*Sida* spp.).

Oi (*Verbena bonariensis*).

Pili grass (*Heteropogon contortus*).

Spanish needle (lauki) (*Bidens pilosa*).

Puakala (*Argemone mexicana*).

Alii (*Dodonœa viscosa* var. *spathulata*).

Hila hila (undetermined).

Other weeds are *Waltheria americana*, *Ipomœa pes-capræ* (vine along sea coast), and *Malvastrum tricuspidatum*.

OTHER SOURCES OF HONEY.

Insect honeydew.—Hawaii is peculiar in that most of the honey produced is from some source other than flowers. Two-thirds of the honey shipped annually from the islands is largely or entirely honeydew honey. By far the greater part of this comes from the exudations of the sugar-cane leafhopper (*Perkinsiella saccharicida* Kirk.) and possibly some of it from the sugar-cane aphis (*Aphis sacchari* Zehnt.), although while on the islands the author observed none of the latter species. (See Pl. IX, fig. 1, showing an apiary near a field of sugar cane.) Of course, in a tropical country there are many other insects producing more or less honeydew. The young "plant cane" is most abundantly covered with leafhoppers.

Honeydew from the sugar-cane leafhopper is very dark amber in color and slightly ropy. In flavor it very strongly resembles molasses from the cane juice. Since the color and flavor are so marked, a small amount of this when mixed with the mild, light-colored algarroba honey imparts the color and flavor of honeydew to the entire amount. Most honeydew honeys on the mainland granulate very rapidly, but this type does not granulate at all. Samples several years old are as clear as when first extracted.

The chemical composition [a] of Hawaiian honeydew honey is quite unlike that of floral honey, and this fact has led to the charge of adulteration by buyers on the mainland and in foreign markets. Since nowhere else, as far as the author is aware, is honeydew honey produced in such large quantities, it is not strange that cursory examinations were misleading. The author saw enough while on the islands to convince him that, however unlike floral honey this product may be, it is a natural sweet product collected and stored by the bee and is then extracted and shipped with no additions of other sugars.

When the food and drugs act of 1906 went into effect the Hawaiian Bee Keepers' Association sent a representative to Washington to find out under what name they could market their crop, since it does not conform to the standard of the Association of Official Agricultural Chemists. They were informed that it could be sold on the mainland market provided it were labeled just what it is. This

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[a] *Chemical composition of Hawaiian honeydew honey made from sugar-cane honeydew.*

[From Bulletin No. 110, Bureau of Chemistry, p. 37.]

Polarization.						Complete analysis.						Free acid as formic.	Reducing sugars as dextrose.	Remarks.
Direct.			Invert.											
Immediate, 20° C.	Constant, 20° C.	Birotation.	20° C.	87° C.	Difference.	Water.	Invert sugar.	Sucrose.	Ash.	Dextrin.	Undetermined.			
+24.9	+17.75	7.15	+13.53	+34.76	21.23	15.46	64.84	5.27	1.29	10.01	3.13	0.15	62.1	High in chlorid.

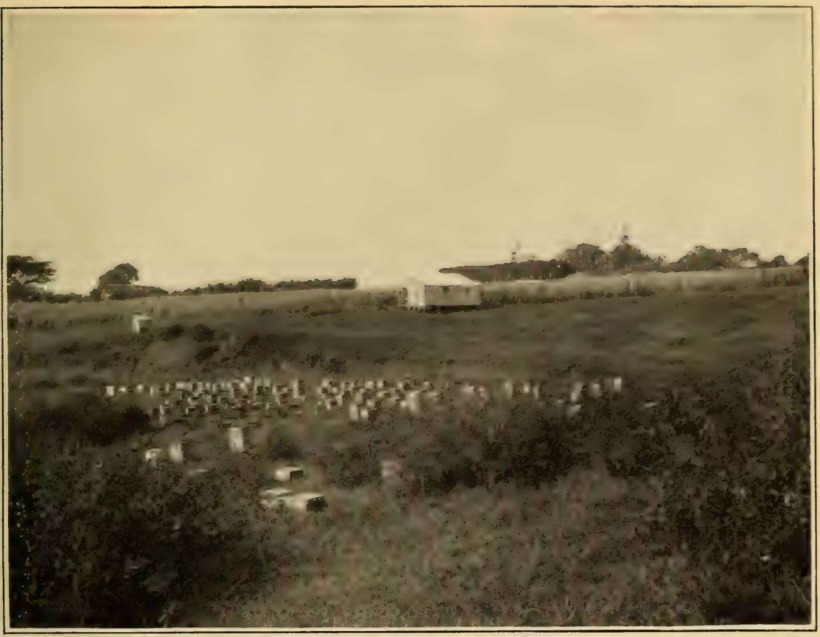

FIG. 1.—AN APIARY NEAR A SUGAR-CANE FIELD. (ORIGINAL.)

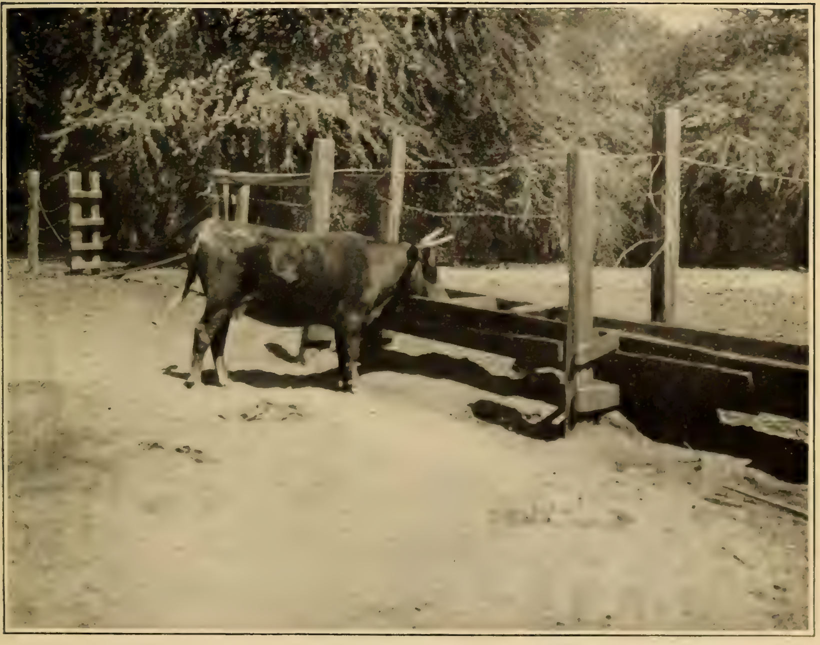

FIG. 2.—MOLASSES TROUGH FOR FEEDING CATTLE. (ORIGINAL.)

the Hawaiian bee keepers have done and it is now sold as "honeydew honey." The bee keepers of Hawaii fully realize the peculiar honey with which they have to deal and are not attempting to market honeydew honey in competition with floral honey for table use. It goes to the baking trade and for such use is reported to be satisfactory: at any rate, the price received is equal to that received for algarroba honey.

As stated elsewhere, bees prefer floral nectar to honeydew. However, when the supply of floral nectar is not great, the bees work on both, and as a result there are mixtures of the two, stored in the hives, varying all the way from the pure honeydew honey to pure floral honey. It is these mixtures that cause the trouble in labeling. One of the requisites of a pure honey as defined by the standards[a] is that it shall be lævorotatory to polarized light; hence, since honeydew honey is dextrorotatory and there are blends made by the bees of this and algarroba honey, it is necessary to have a chemical analysis made to be absolutely certain whether a given quantity of the product of the islands may be sold as honey or as honeydew honey. The various mixtures which occur are well illustrated in Plate I of Bulletin 110, Bureau of Chemistry, here reproduced as Plate VI. This plate illustrates very well the influence of honeydew on the physical properties of honey. At one end of the series is the pure algarroba, which is represented as granulated, while at the other end is a sample of honeydew honey which is as pure as it is usually found. Between the two in perfect gradation are shown various mixtures just as they came from the hive in various extractings. The chemical analyses of these particular samples, made by Miss Alice R. Thompson,[b] show that the chemical composition varies in exactly the same way. Of these samples, Doctor Browne[c] says:

> From the polarizations and analyses of these samples (as given in the table) it will be seen that there is a range in direct polarization from —22.0 to

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[a] U. S. Dept. Agr., Office of the Secretary, Cir. 19, p. 11.

[b] *Polarization and analyses of honeydew blends.*

[From Bul. 17, Hawaii Agr. Exp. Sta.]

Data.	Algarroba honey.	Blends.								Honeydew.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Polarization direct (°V)	−22.00	−18.3	−14.3	−8.7	−0.3	+0.5	+4.0	+8.9	+19.2	+24.5
Polarization invert (°V)	−27.61	−21.4	−17.3	−11.5	−3.8	−4.2	−1.0	+3.2	+12.4	+15.3
Sucrose (percent)	3.58	2.4	2.3	2.2	2.7	3.7	2.3	4.5	5.3	7.2
Reducing sugar (per cent)	76.84	76.64	77.28	72.36	65.56	66.16	67.28	63.08	58.92	59.76
Ash (per cent)	.34	.58	.69	.72	1.06	1.11	1.12	1.33	1.77	2.04
Nonsugars (per cent)	1.41	1.67	1.81	7.17	13.52	12.09	11.84	15.27	17.68	15.88

[c] Bul. 110, Bureau of Chemistry, pp. 55–56.

+24.5; in ash, from 0.34 per cent to 2.04 per cent; in reducing sugars, from 76.84 per cent to 59.76 per cent; and in organic matter not sugar, from 1.41 per cent to 15.88 per cent. In sucrose also there is an irregular increase from 3.58 to 7.2 per cent, this increase becoming more regular as soon as the quantity of honeydew is sufficient to mask the variation in sucrose content of the individual honeys in the series of blends. The granulation of the blends decreases with the increase of honeydew and ceases at about the point of optical inactivity. The latter point, as has been said, is taken by the chemist as the arbitrary dividing line between normal and abnormal honeys, and bee keepers in the Hawaiian Islands who are troubled with honeydew have in the matter of granulation a rough guide for the classification of their product. If the honey granulates, it may be put in the normal class; if it remains liquid for any length of time, it probably belongs to the class of honeydews. This statement does not apply in general to mainland honeys.

The dextrorotatory honeydew honeys can not be regarded as adulterated, in the strictest sense of the word; nevertheless they are frequently so pronounced by chemists, who, in the general work of routine, are often satisfied with a most superficial examination, and regard dextrorotation or high ash content as certain evidence of adulteration.

There is a test which may be applied with considerable safety. Algarroba honey granulates rapidly and pure honeydew honey does not; it has been found by analysis that mixtures which granulate are as a rule of such a chemical composition that they may be sold as honey. The flavor and color may be characteristic of honeydew honey in spite of the fact that the mixture contains enough floral honey to be sold as such.

The sugar-cane leafhopper was first collected on the islands by Dr. R. C. L. Perkins, now connected with the Hawaiian Sugar Planters' Agricultural Experiment Station, in 1900,[a] and by February or March of 1903 had "appeared generally throughout the cane fields of Hawaii in numbers sufficient to prove a serious check to the growth of the cane."[b] For several years the work of this insect caused a loss of about $3,000,000 annually[c] to the planters, and naturally they were anxious that something be done to stop this heavy loss. By various means the leafhopper has been brought under control until to-day it is not abundant enough to hinder the growth of the plants, "and plantations that were to a certain extent abandoned are again producing heavy crops of sugar."[d]

During the time spent on the islands the author saw no sugar-cane fields that were seemingly injured by the leafhopper, but, on the other hand, there were no cane fields examined that did not contain many leafhoppers. The fact that the leafhopper is not doing damage enough to hinder cane raising does not signify that it has disappeared, nor is there any biologic reason for believing that it will, while cane is grown, unless some entirely new methods of fighting it are found. The fact that 400 tons[a] of honeydew are produced annually from this source in spite of the fact that only a limited amount of the cane area is accessible to bees is a certain indication of the untold millions of these insects which still exist.

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[a] The Leaf-Hopper of the Sugar Cane, by R. C. L. Perkins. Bulletin No. 1, Division of Entomology, Board of Commissioners of Agriculture and Forestry, Territory of Hawaii, 1903.

[b] The Sugar Cane Leaf-Hopper in Hawaii, by D. L. Van Dine. Bulletin No. 5, Hawaii Agricultural Experiment Station, 1904.

[c] Report of the Governor of Hawaii to the Secretary of the Interior for the fiscal year ending June 30, 1907, p. 22.

[d] Ibid.

The leafhoppers exude a sweet, gummy substance on the leaves of the cane and the honey bees work on this eagerly. However, where bees have access to both honeydew and floral nectar, they prefer the nectar to a marked degree. When algarroba begins to bloom the honey stored becomes noticeably whiter.

In view of the fact that honeydew honey has the taste and color of common molasses, it has been suggested that probably this product is gathered by the bees from the sugar mills which are so numerous on the islands. The writer visited several such mills located near apiaries on days when bees were actively flying. No bees were to be seen anywhere around the mill. If bees actually did come to the mill after sweets, they would become a serious nuisance to the workmen. Why they do not is something of a mystery to the writer, but he can vouch for the fact that he saw no mills screened to keep bees out, nor did he see any bees at work in the mill or even on the pile of sweet refuse ("mud cake") outside.

Molasses is used quite extensively for feeding cattle on the islands. It is poured out in troughs or half barrels where the cattle can get it easily, and frequently these are located near apiaries. Many of these were examined as the writer went about among the apiaries, and in not a single instance did he ever see a bee at work on the molasses. In some cases these feeding troughs are as near as a quarter of a mile to apiaries. A dairyman near Waimea, Kauai, whose trough (Pl. IX, fig. 2) is located not a quarter of a mile from a large apiary, informed the writer that he had never seen bees working on the molasses. Obviously, Hawaiian honeydew honey does not come from this source.

Extra-floral plant honeydew.—The situation in Hawaii as regards sources of honey is made still more complicated and interesting by the fact that the hau tree (*Paritium tiliaceum*) has nectaries on its leaves which secrete a honeydew. These are located on the veins of the leaves near the stem and are one, three, or five in number. Small drops of honeydew may frequently be seen on these spots. It is interesting to note that these extra-floral nectaries are present on the outside of the calyx of the flowers. There is apparently no true floral nectary.

---

[a] Five hundred tons in 1908.

The hau tree is used quite extensively as a hedge, and grows from 20 to 30 feet high (Pl. X, fig. 1). It is doubtful whether this is the source of any great percentage of the honeydew honey, but the fact that it is present makes it still more difficult to analyze the bee-keeping situation on the islands.

INTRODUCTION OF HONEY PLANTS.

In addition to the nectar-secreting plants now found on the islands, either as native plants or as recently introduced, the bee keepers are anxious that other good honey-producing plants be introduced to increase still more the amount of floral honey. As before stated, bees show a marked preference for floral nectar over honeydew. There is on the islands a great deal of land which is not only not cultivated at present, but which, from its rough character, can never be cultivated. There is doubtless an opportunity for the introduction of some honey plants to the mountainous regions, where they would not interfere with cultivated crops or grow on land of value for any other purpose.

From the sad experiences in plant introductions on the islands, it will be well to watch any new honey-plant introductions very carefully. Lantana, which is used so much as a greenhouse plant on the mainland, was introduced a few years ago. It soon escaped from the greenhouse, however, and found in the climate of the islands the proper conditions for rank rapid growth. It spread to all the islands and forms dense jungles 10 feet or more in height, through which it is impossible to pass without cutting a path (Pl. VIII, fig. 2). Various methods are being tried with a view to exterminating this pest, but to-day there is still plenty of lantana. The cost of clearing a lantana thicket for cultivation is about $10 an acre. Lantana secretes nectar, but that is the only good thing which can be said for it. It was, of course, not introduced for its honey, but this experience should make the bee keepers cautious about what plants they bring in. The sages of California are now being tried, as well as various kinds of mangroves.

WAX PRODUCTION.

The price of honey fluctuates relatively much more than that of beeswax. On account of the fact that Hawaiian honey has been selling for a low price and also because of the peculiar character of most of the honey, the bee keepers of the islands are desirous of converting their honey into wax, if it can be done, even at no great profit. The long shipment necessary to get their honey to market means more or less loss by leakage and heavy freight. Wax does not lose anything

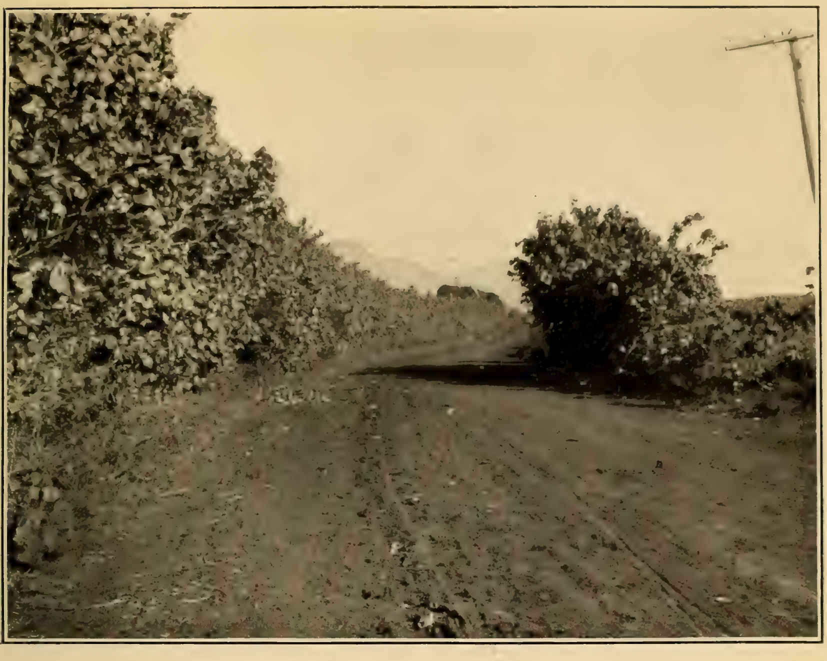

FIG. 1.—HAU HEDGE. (ORIGINAL.)

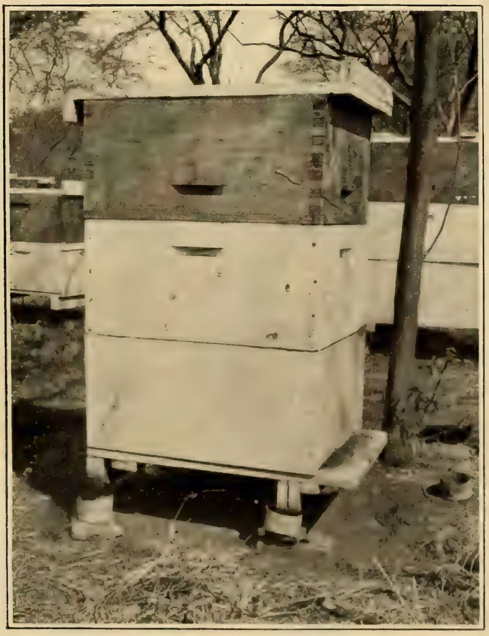

FIG. 2.—A HIVE SET UP IN CANS TO KEEP OUT ANTS. (ORIGINAL.)

in transit, and naturally also wax weighs much less than an amount of honey of equal money value, and the freight would be very much reduced.

When the author arrived on the islands one of the first questions asked him was how to bring about a production of more wax and less or even practically no honey. After getting the available data, which were freely given, a method was suggested which promises to give some results, if we may judge by results obtained in some experiments conducted in the short time which could be spent in Hawaii. Before outlining this proposed method it will be well to review the basis for the recommendations.

It is a well-known fact among bee keepers that at the time a swarm is hived the activity of the inmates of the new home is at its height. The bees not only collect nectar with great vigor, but, there being no wax in the hive under natural conditions, the wax secreters become very active and in a marvelously short time the hive is supplied with combs. It is also true, of course, that wax is secreted at any time during the active season when it is necessary that more combs be built to accommodate brood or stores, provided, of course, that there is room. If a comb is removed from the center of the brood chamber or from the super, it is replaced as needed, but, as a rule, not so rapidly. The rapidity of the honey flow influences this wax secretion greatly.

The amount of honey consumed in the secretion of a pound of wax is a much-debated question among students of bees, the various estimates ranging all the way from 2 to 20 pounds. There seems to be little hope at present of arriving at anything definite on this question, and the author is strongly inclined to the belief that the reason for this great variation in estimates is due to the fact that the same amount of honey is not always needed to bring about a desired result. It would be bootless, therefore, to pay any attention to this phase of the question in trying to get a method of wax production. Sylviac, in a series of articles in L'Apiculteur for 1901, offers evidence that the amount of honey consumed in secreting a pound of wax is least following swarming, and this quite coincides with the fact that wax building is most rapid at that time.

In dealing with wax secretion on a commercial basis, data must be drawn from the receipts per colony under different methods of management. The actual consumption of honey becomes of minor importance. It was learned that the average annual return per colony, after deducting freight charges, leakage, and other expenses incurred after the honey leaves the apiary, would not exceed $2.50. The hives are on an average two stories high during the entire year and, during the height of the honey flow, are often higher. All figuring was done on a basis of two-story colonies. The wax in such a hive weighs over 6 pounds,[a] averaging in value $1.80, Hawaiian wax being of the finest quality.

As additional data, it was learned that it is possible to increase the number of colonies very rapidly. In one remarkable case reported, 20 colonies were increased to 420 in eight months. This fact shows that a colony of bees can build up very rapidly under the conditions existing on the islands. It must also be remembered that in cane sections there is practically no stopping of the honey flow.

In view of all these facts it was obvious that if the wax be taken from each colony it will form a good beginning in the annual return from a colony. If, then, the colony is in as good shape in a year's time as it was when the wax was removed, there will be honey enough stored to make the annual money return higher than if the colony had been run for honey alone.

The method recommended is to shake the colony onto starters of foundation. The brood is placed over another colony to develop so that it may not be lost; the honey is to be extracted. By dividing the apiary into two parts, one-half may be shaken and the brood piled on the other half. These in turn may be shaken in three weeks or more and their brood added to the colonies shaken at first. This manipulation is identical with the shaking in treating for bee disease. Similar methods are often employed in honey producing to prevent swarming and to cause bees to work in the supers. In the present instance, however, there is an entirely different reason for the practice.

In the trial made with a view to wax production, a surprising showing was made, and it seemed obvious that the operation could be repeated in not more than three months' time, and probably less. If this be true, then there will be removed $1.80 worth of wax or more at each shaking, which means a considerable gain.

No positive statements of results can be made until the method has stood trial for a time. If this plan serves the purpose in Hawaii, it will also be valuable in other regions where there is a heavy honey flow for a long time.

DISEASE SURVEY.

The bee keepers of the islands were very anxious to learn whether or not they had any brood disease among their bees. They were quite certain that there was none, but desired this opinion to be confirmed. For this reason the apiaries visited were carefully examined by the author and absolutely no trace of any known infectious disease was found. In view of the fact that a brood disease would spread rapidly in that climate, the bee men may consider themselves extremely fortunate.

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[a] Since this was written the writer has received a report, dated May 19, 1908, on this series of experiments, showing that 8.88 pounds were extracted from 20 frames, this being the actual average in an apiary of 120 colonies.

Some time ago Mr. D. L. Van Dine sent to the Bureau of Entomology a sample of brood which had died, and it was reported that there had been considerable loss on this account. There was no indication of any infectious disease in the sample, and before another sample could be obtained the trouble had disappeared. Of this trouble Mr. Van Dine wrote, under date of April 27, 1906:

> About the 1st of January it began and appeared simultaneously in several of the apiaries of the ——— Honey Company. In the majority of cases [of hives having this trouble] from one-half to three-fourths of the brood died when the larvæ were nearly full grown or after transforming to the pupæ. The sunken caps and black color resembled the descriptions of foul brood, but there was no odor or other symptoms. Many of the pupæ showed signs of life after turning nearly black and some adults emerged before dying * * *. As a precaution the bees were fed medicated sirup, but I am of the opinion that the trouble is not an infectious disease, but due to improper food. When the algarroba, our principal honey tree, had ceased to flower the main source of pollen was gone, but the bees could still get an abundance of honey from the sugar cane. The bee bread was scanty, very dark in color, and rather hard. I have not been able to trace out where they got it. Probably from various weeds * * *. The algarroba is coming in flower again and it is a fact that the trouble is fast disappearing, and I am inclined to believe that it was due to the food conditions I mentioned * * *.
>
> On the island of Kauai the same trouble appeared at the same time as on this island and the conditions are exactly the same. On the island of Molokai the trouble did not occur and there they have no sugar cane and when the honey plants failed the queens ceased to lay and no outbreak of the disease occurred.

Under date of June 5, 1906, he wrote:

> For a time after the bees began to bring in pollen in abundance the trouble seemed to disappear, but just now in certain colonies it is as serious as ever. This seems to contradict the idea that the trouble is due to food conditions.

While the author was on the islands only one case was seen which resembled what was described in 1906. This was in an apiary on the island of Kauai. The dead larvæ in no way resembled those which die of American foul brood or European foul brood. There is no indication that the trouble is contagious, and the dead larvæ resembled certain phases of what is generally called "pickle brood."

The bee keepers are anxious that no disease be allowed to enter their territory, and at the request of the Hawaiian Bee Keepers' Association the author drew up a letter of recommendation which is here given:

> For the information of your association in formulating proposed regulations relative to the establishment of an effective quarantine against the various diseases of the bee, I take pleasure in presenting the following statements as my opinion concerning the questions involved.

1. *The nature of the diseases.*—There are now recognized two diseases, virulent and contagious in their character, which attack the brood of the bee. These are known as American foul brood and European foul brood. It is definitely known that American foul brood is caused by a bacterium, *Bacillus larvæ*, and from the symptoms and behavior of European foul brood it is almost certain that the latter disease is likewise caused by a micro-organism. There are other diseases recognized by bee keepers, but it is not known that they are infectious.

2. *Methods of spread.*—It is known that both diseases mentioned (European foul brood and American foul brood) are transmitted in the following manners:

(*a*) By bees from healthy colonies robbing the hives of diseased colonies.

(*b*) By the bee keeper feeding honey from diseased colonies, as in the case of feeding for winter stores in the colder parts of the mainland.

(*c*) By the accidental feeding of honey from diseased colonies, which has been extracted and sold in bottles or other containers. (This applies to partly empty honey bottles or cans which may be thrown out carelessly where bees can gain access to them.)

(*d*) By the introduction of queens taken from apiaries in which disease is present and which are shipped in cages stocked with candy made from infected honey.

It will be obvious from the local conditions that (*b*) does not apply to the Hawaiian Islands. It is doubtless true also that (*a*) does not apply. I can not say positively that neither disease is present in the Territory, but it is almost certain that they are not.

Means of preventing the introduction of disease to the Hawaiian Islands.—As an immediate action, it is desirable that all queens which are shipped to the Territory be removed from the cages in which they arrive and be introduced to colonies from a clean cage containing candy made from honey free from disease organisms. This precaution, which is a very simple operation, will be a very good assurance that disease will not be brought to your islands with imported queens.

It is desirable that as soon as possible a quarantine apiary be established, to which all imported queens shall be introduced. After two months' time, if the colonies to which the queens are introduced are free from disease, the queens may be sent to the owner with perfect safety.

It is above all desirable that no honey of any kind shall be shipped to your islands unless it comes from healthy colonies and is accompanied by a certificate of a qualified inspector of apiaries that such is the case. This precaution is of much more importance than those against infection through importation of queens. The bee keeper who imports queens would probably soon recognize disease if it appeared in a colony containing a choice imported queen, but if disease is brought in with honey it might gain a strong foothold before its discovery. This provision will not constitute a prohibition of the importation of honey, since on the mainland there are now about 55 qualified apiarian inspectors.

On September 2, 1908, the Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii passed regulations pertaining to the importation and inspection of honey bees and honey, which placed restrictions on such importations for the purpose of preventing the introduction of contagious diseases.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 75, Part VI.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

THE STATUS OF APICULTURE IN THE UNITED STATES.

BY

E. F. PHILLIPS, Ph. D.,
In Charge of Apiculture.

Issued January 25, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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U. S. D. A., B. E. Bul. 75, Part VI. A., January 25, 1909.

MISCELLANEOUS PAPERS ON APICULTURE.

THE STATUS OF APICULTURE IN THE UNITED STATES.

By E. F. Phillips, Ph. D.,
In Charge of Apiculture.

INTRODUCTION.

Few persons realize the magnitude, importance, and possibilities of the present bee-keeping industry in the United States. Those who are conversant with the pursuit, and even those who are extensively engaged in it, generally fail to comprehend what an important factor in the agriculture of the country apiculture is as a whole, or how much the honey bee, by collecting nectar and storing it to produce a commercial product, is instrumental in saving our resources. Although the total value of bee products is small as compared with the value of the products of many other branches of agriculture, it nevertheless has an importance which should not be overlooked. The object of this paper is to review the present status of the industry with a view to pointing out where we may look for advancement.

Few rural pursuits have made greater progress during the past half century than has this one. Before that time the bees of this country were kept in box hives, and as a result the annual average crop of honey per colony was small. In addition to this handicap in not being able to manipulate the bees as was needed, bee keepers generally lacked a knowledge of the methods of caring for them. With the invention of movable-frame hives by Langstroth in 1851 it became possible to care for bees properly and to manipulate in such a way as to get the best crop. As the use of this type of hive and of the honey extractor became general, bee keepers have become better educated in modern methods of manipulation, and the industry has advanced from a negligible quantity to its present important place in agriculture.

In the vast majority of cases bee keeping is not the principal occupation, but is carried on in conjunction with some other business.

According to the census of 1900 the average number of colonies on farms reporting them was 5.8106, valued at $14.40—a very small investment. In some recent work of this Bureau[a] it has been found that in the State of Massachusetts the average number of colonies reported was 5.5 per bee keeper. This last figure should not be taken as an index to the condition in the whole country, for as one goes farther west the holdings are found to be larger. In California, for example, while there are some small apiaries, the majority are quite large, and the average is several times that of Massachusetts. The number taken from the census can scarcely be accepted as correct.

The number of men who rely solely on the production of honey and wax for a livelihood is rather small, and most of the extensive producers of the West carry on some other business, at least for the part of the year when the bees are less active. The reason for this is found in the nature of the industry. Any location is limited as to the number of colonies of bees which it will support, and in consequence a bee keeper must either carry on some other business or establish numerous outapiaries to enable him to keep bees enough to make it an occupation which will support him. Since the establishment of outapiaries is attended with certain disadvantages, it usually follows that bee keeping becomes a minor part of a man's occupation or even a side line.

Then, too, bee keeping is taken up by many as a recreation or a subject of nature study. Such persons do not wish to make it their sole or main occupation. Many farmers also keep a few colonies of bees and add to their income to some extent in that way. It is obvious that bee keeping must continue to be an avocation in the majority of cases.

This brings up for consideration a question which has been much discussed by those interested in bringing about an advance in the industry: Shall an attempt be made to increase the number of bee keepers, or to make better ones of a smaller number? Bee keepers who follow the pursuit on a commercial scale are usually anxious that there be no increase in the number engaged in the business, but rather a decrease, with an accompanying advance in the proficiency of those so engaged. This desire is not wholly selfish, for unless the increase is directly in the territory of the individual his crop is not affected.

It frequently happens that a local market is ruined, temporarily at least, by some uninformed bee keeper who keeps a few colonies and sells a poor grade of honey for a ridiculously low price, thus making it almost impossible for the up-to-date bee keeper to sell his honey for what it is worth in the same community. This condition of affairs would not occur were it not for the fact that, for table use at least, honey does not rank as a necessity, and the usual causes for changes in market price do not operate so completely as is the case with other commodities.

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[a] Gates, Burton N.—Bee Keeping in Massachusetts. Bulletin No. 75, Part VII, Bureau of Entomology, U. S. Dept. of Agriculture. (In preparation.)

The main objection to numerous small bee keepers, rather than fewer and more expert ones deeply engaged in the industry, is, that when the larger number is interested it can not be hoped that all will become proficient. Under normal circumstances this matters little, since anyone has a right to neglect his bees if he so desires, but when some contagious disease is present in a region this becomes a serious matter. The expert bee keeper can not hope to rid his bees of disease if there are a great many unqualified bee keepers in his neighborhood. Under such a circumstance—which unfortunately is becoming quite general in this country—the negligent bee keeper keeps property which, if diseased, constitutes a nuisance, and is a constant menace to the progressive man, for it is impossible to tell when neglected colonies may become infected.

If progress is to be made toward getting the largest possible honey crop from the United States, it will hardly be done by making bee keepers who own an average of 5 colonies. It must be done by progressive bee keepers financially interested to an extent sufficient to compel them to combat disease and to do their utmost to get the entire crop. We may not hope to attain this ultimate condition, but an effort might be made to discourage negligent and indifferent bee keeping.

In spite of the fact that bee keeping is the sole occupation of but few, it nevertheless commands attention in that it adds considerably to the resources of the country and increases the income of thousands of people. The possibilities for its increase are great, and the advancement of this vocation is a worthy object as aiming to save for human use a resource which is now so generally wasted.

SCOPE OF THE INDUSTRY.

It is very difficult to estimate accurately the annual value of the products of the apiary, but from various sources of information it is reasonable to suppose that the value of the honey produced annually in the United States is on the average about $20,000,000 and of wax about $2,000,000. Since the honey harvest depends so completely on various climatic conditions affecting the secretion of nectar, it is obvious that there is an enormous variation in the annual yield.

As nearly as can be learned, the number of sections for comb honey manufactured annually by supply dealers is between 60,000,000 and

75,000,000, and that may be considered as a fair estimate of the average number of pounds of comb honey produced in the United States, since relatively few sections are exported. Extracted honey is produced more extensively, and it is safe to say that the annual crop is three or four times that of comb honey. Taking into consideration also the chunk honey sold and the honey not marketed but used in home consumption, the estimate of $20,000,000 is none too high.

It may be of interest to compare the data of various years given by the census. Table I gives the amount of honey and wax, with the ratio between them. It is very interesting to note a reported increase in the ratio of honey to wax produced as the use of the honey extractor has become more general.

TABLE I.—*Production of honey and wax in the United States, 1840–1900.*

Census of—	Honey.	Wax.	Ratio of honey to wax.
	Pounds.	*Pounds.*	
1840		628,303	
1850	[a] 14,853,790		
1860	23,366,357	1,322,787	17.7:1
1870	14,702,815	631,129	23.3:1
1880	25,743,308	1,105,689	23.3:1
1890	63,897,327	1,166,588	54.8:1
1900	61,196,160	1,765,315	34.7:1

[a] Beeswax and honey.

The last census, that of 1900, recording crop data for 1899, gives the following:

Total number of farms reported in census		5,739,657
Number of farms reporting bees		707,261
Percentage of total		12.3
Number of colonies, June 1, 1900		4,109,626
Average number per farm reporting bees		5.8106
Value of bees		$10,186,513
Pounds of honey in 1899		61,196,160
Pounds of wax in 1899		1,765,315
Value of honey and wax in 1899		$6,664,904
Number of farms of white farmers reporting bees		677,985
Percentage of all farms of white farmers		13.6
Number of farms of colored farmers reporting bees		29,276
Percentage of all farms of colored farmers		3.8
Average crop per farm reporting bees:		
Honey	pounds	86.5
Wax	do	2.5
Average value of honey and wax per farm reporting bees		$9.42
Average value of bees per farm reporting		$14.40
Average value of bees per colony		$2.48
Average pounds of honey per colony		14.9
Average pounds of wax per colony		.43
Average value of honey and wax per colony		$1.62

Tables II and III[a] give additional data on distribution.

TABLE II.—*Number and value of swarms*[1] *of bees, June 1, 1900, on farms and ranges, by geographic divisions.*

Geographic division.	Number of farms.	Farms reporting bees.	Per cent of farms reporting bees.	Swarms of bees.	Value of bees.
The United States	5,739,657	707,261	12.3	4,109,626	$10,186,513
North Atlantic	677.506	64,110	9.5	413.709	1,370,732
South Atlantic	962,225	151,863	15.8	854.909	1,664,636
North Central	2,196,567	233,721	10.6	1,187,856	3,505.675
South Central	1,658,166	225,100	13.6	1,289,384	2,513,397
Western	242,908	32,421	13.3	362,381	1,123,647
Alaska and Hawaii	2.285	46	2.0	1,387	8,426

[1] The word "swarms" used in census reports evidently should be "colonies."

TABLE III.—*Pounds and value of honey and wax produced on farms and ranges in 1899, with averages per farm reporting, by geographic divisions.*

Geographic division.	Honey.		Wax.		Value of honey and wax.	
	Total.	Average per farm.	Total.	Average per farm.	Total.	Average per farm.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*		
The United States	61,196,160	86.5	1,765,315	2.5	$6,664,904	$9.42
North Atlantic	6,855,027	106.9	182,819	2.9	801,147	12.50
South Atlantic	9,468,843	62.4	379,192	2.5	1,029,233	6.78
North Central	20,055,502	85.8	396,604	1.7	2,353,001	10.07
South Central	14,849,824	66.0	588,960	2.6	1,553,141	6.90
Western	9,870,094	304.4	216,020	6.7	920,089	28.38
Alaska and Hawaii	96,870	2,105.9	1.720	37.4	8,293	180.28

Taking the number of farms keeping bees as the basis, the five most important bee-keeping States, June 1, 1900, were Texas, with 60,043 farms reporting; Kentucky, with 44,974; Missouri, with 41,145; North Carolina, with 41,051; and Tennessee, with 38,225.

Taking the number of swarms, or colonies, of bees as the basis, the five leading States were Texas, with 392,644; North Carolina, 244,539; Tennessee, 225,788; Alabama, 205,369; and Missouri, 205,110. Of the States included in the series given first, Texas, Missouri, Tennessee, and North Carolina are found in the second.

Taking the value of the bees as the basis of classification, the five leading States were Texas, with $749,483; New York, $593,784; Pennsylvania, $531,578; Kentucky, $527,098; and Missouri, $508,217.

The five greatest producers of honey in 1899 were Texas, with 4,780,204 pounds; California, 3,667,738; New York, 3,422,497; Missouri, 3,018,929; and Illinois, 2,961,080. California, which has not been included in any of the preceding classifications, here stands second.

Of the States producing wax, Alabama led with 162,020 pounds; Texas was second, with 159,690; North Carolina third, with 135,920; California fourth, with 115,330; and New York fifth, with 84,075.[b]

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[a] Twelfth Census of the United States, 1900, Vol. V, Agriculture, Part I, p. ccxxxiii.

[b] Twelfth Census of the United States, 1900, Vol. V, Agriculture, Part I, pp. ccxxxiii–ccxxxiv.

It will be noticed that the data on honey and wax crops do not at all agree with the author's estimate given above. In the light of the evidence previously given, it is obvious that the census figures are entirely too small and are far from doing justice to the industry. The other data are probably much more reliable. It is hardly a fair test to compare 1900 data as to the number of bee keepers with those of 1906, but it should be noted that in the recent work of the Bureau in Massachusetts [a] there were reported 2,127 bee keepers as compared with 1,799, the number given in the census.

IMPORTS AND EXPORTS.

Tables IV to VII show the imports and exports of honey and wax through the ports of entry of the United States. The data for these tables were obtained through the courtesy of the Bureau of Statistics of this Department.[b]

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[a] Gates, Burton N.—Bee Keeping in Massachusetts. Bulletin No. 75, Part VII, Bureau of Entomology, U. S. Dept. of Agriculture. (In preparation.)

[b] Tariff schedules on honey and wax under the different acts of Congress subsequent to 1841 are as follows:

Acts of—	Tariff on honey.	Tariff on wax.
August 30, 1842	Not specifically mentioned	15 per cent ad valorem.
July 30, 1846	30 per cent ad valorem	20 per cent ad valorem.
March 3, 1857	24 per cent ad valorem	15 per cent ad valorem.
March 2, 1861	Not specifically mentioned	10 per cent ad valorem.
July 14, 1862	15 cents per gallon	20 per cent ad valorem.
June 30, 1864	20 cents per gallon	Not specifically mentioned.
March 3, 1883	20 cents per gallon	20 per cent ad valorem.
October 1, 1890	20 cents per gallon	Free.
August 27, 1894	10 cents per gallon	Free.
July 24, 1897	20 cents per gallon	Free.

TABLE IV.—*Imports of honey into the United States, 1901-1908, by countries from which consigned.*

Year ending June 30—	Cuba.				Mexico.			
	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.
1901	809,784	$31,591	3.9	37.0	727,728	$25,659	3.5	33.3
1902	131,736	5,807	4.4	6.6	1,361,052	33,269	2.4	67.8
1903	1,565,088	64,867	4.1	45.3	1,166,796	31,697	2.7	33.8
1904	1,296,912	42,597	3.3	52.4	652,404	12,345	1.9	26.3
1905	1,575,768	57,918	3.7	66.1	516,804	10,477	2.0	21.7
1906	756,312	26,239	3.5	45.6	724,488	18,107	2.5	43.7
1907	915,744	33,380	3.6	43.4	884,340	27,534	3.1	42.0
1908	1,162,872	46,726	4.0	45.7	1,045,944	37,926	3.6	41.1

Year ending June 30—	Santo Domingo.				Haiti.			
	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.
1901	327,876	$13,091	4.0	15.0	146,256	$5,086	3.5	6.7
1902	160,440	4,853	3.0	8.0	35,184	1,173	3.3	1.7
1903	198,204	4,897	2.5	5.8	255,588	5,013	2.0	7.4
1904	373,212	8,982	2.4	15.1	58,476	1,273	2.2	2.4
1905	162,792	4,063	2.5	6.8	44,052	779	1.8	1.9
1906	27,840	820	2.9	1.7	81,444	1,703	2.1	4.9
1907	31,272	746	2.4	1.5	188,640	4,849	2.6	8.9
1908	49,068	1,376	2.8	1.9	106,116	2,870	2.7	4.2

Year ending June 30—	All other countries.				Total.		
	Pounds.[a]	Value.[b]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.[a]	Value.[b]	Average price per pound in cents.
1901	174,708	$8,172	4.7	8.0	2,186,352	$83,599	3.8
1902	319,200	11,281	3.5	15.9	2,007,612	56,383	2.8
1903	266,676	8,926	3.3	7.7	3,452,352	115,400	3.3
1904	94,500	3,856	4.1	3.8	2,475,504	69,053	2.8
1905	83,988	3,482	4.1	3.5	2,383,404	76,719	3.2
1906	68,568	3,782	5.5	4.1	1,658,652	50,651	3.1
1907	88,068	4,345	4.9	4.2	2,108,064	70,854	3.4
1908	179,904	9,527	5.3	7.1	2,543,904	98,425	3.9

[a] Custom-house returns of honey are given in gallons, assumed here to weigh 12 pounds.

[b] Imports of honey into the United States are subject to a specific duty.

Values.—The values of all imported articles, whether subject to ad valorem or specific duties or free of duty, are regulated by the act of Congress of June 10, 1890.

The actual market value or wholesale price of such merchandise as bought and sold in usual wholesale quantities at the time of exportation to the United States in the principal markets of the country from whence imported, and in the condition in which such merchandise is there bought for exportation to the United States or consigned to the United States for sale, including the value of all cartons, cases, crates, boxes, sacks, and coverings of any kind, and all other costs, charges, and expenses incident to placing the merchandise in condition ready for shipment to the United States.

Valuation deceptions.—The value of imported articles subject to ad valorem duties is believed to be determined with more accuracy, according to the legal method of valuation, than other imports, with specific duties or free, and exported articles; the valuation of dutiable imports and of exports dutiable in foreign countries tend to understatement, and the valuations of imports that are free of duty are often inflated for the purpose of trade deception.

TABLE V.—*Imports of beeswax into the United States, 1901–1908, by countries from which consigned.*

Year ending June 30—	Cuba.				Mexico.			
	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.
1901	110,778	$28,539	25.8	51.8	13,446	$3,080	22.9	6.3
1902	157,839	44,364	28.1	38.6	23,366	5,070	21.7	5.7
1903	147,917	42,357	28.6	30.3	162,332	36,476	22.5	33.2
1904	98,455	28,682	29.1	23.1	167,843	45,673	27.2	39.5
1905	79,926	24,006	30.0	21.4	87,943	23,265	26.5	23.5
1906	158,523	48,120	30.4	27.0	46,421	13,485	29.0	7.9
1907	331,942	93,702	28.2	36.2	47,262	15,417	32.6	5.2
1908	264,984	76,431	28.8	39.5	41,489	13,290	32.0	6.2

Year ending June 30—	Santo Domingo.				Haiti.			
	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.
1901	41,225	$10,241	24.8	19.3	11,286	$4,292	38.0	5.3
1902	73,364	21,118	28.8	17.9	6,373	3,013	47.3	1.6
1903	82,829	21,364	25.8	16.9	25,276	7,692	30.4	5.2
1904	80,783	21,061	26.1	19.0	38,106	10,359	27.2	9.0
1905	46,816	11,193	23.9	12.5	62,547	16,047	25.7	16.8
1906	34,052	8,596	25.2	5.8	27,311	7,326	26.8	4.6
1907	67,264	16,941	25.2	7.3	48,831	13,555	27.8	5.3
1908	55,311	13,085	23.7	8.2	58,147	15,379	26.4	8.6

Year ending June 30—	All other countries.				Total.		
	Pounds.	Value.[a]	Average price per pound in cents.	Percentage of total imports from all countries.	Pounds.	Value.[a]	Average price per pound in cents.
1901	37,038	$9,732	26.3	17.3	213,773	$55,884	26.1
1902	147,764	42,372	28.7	36.2	408,706	115,937	28.4
1903	70,222	19,331	27.5	14.4	488,576	127,220	26.0
1904	39,981	11,103	27.8	9.4	425,168	116,878	27.5
1905	96,337	26,610	27.6	25.8	373,569	101,121	27.1
1906	321,310	90,487	28.2	54.7	587,617	168,014	28.6
1907	421,789	125,022	29.6	46.0	917,088	264,637	28.9
1908	251,595	76,584	30.4	37.5	671,526	194,769	29.0

[a] Imports of beeswax into the United States are free of duty.

Values.—The values of all imported articles, whether subject to ad valorem or specific duties or free of duty, are defined by the act of Congress of June 10, 1890, as—

The actual market value or wholesale price of such merchandise as bought and sold in usual wholesale quantities at the time of exportation to the United States in the principal markets of the country from whence imported, and in the condition in which such merchandise is there bought for exportation to the United States or consigned to the United States for sale, including the value of all cartons, cases, crates, boxes, sacks, and coverings of any kind, and all other costs, charges, and expenses incident to placing the merchandise in condition ready for shipment to the United States.

Valuation deceptions.—The value of imported articles subject to ad valorem duties is believed to be determined with more accuracy, according to the legal method of valuation, than the value of imports with specific duties or free of duty, or the value of exported articles; the valuations of dutiable imports and of exports dutiable in foreign countries tend to understatement, and the valuations of imports that are free of duty are liable to inflation for the purpose of trade deception.

Table VI.—*Imports and exports of honey of the United States, 1855–1908.*

[The terms "Comb" and "Extracted" honey used in these headings are used in place of "Unstrained" and "Strained" honey in the reports of the Department of Commerce and Labor.]

Year ending June 30—	Imports.			Exports.[a]		
	Pounds.	Value.	Average price, in cents.	Comb.	Extracted.	Both comb and extracted.
1855	5,245,908	$138,189	2.63			
1856	5,142,432	169,643	3.30			
1857	4,975,908	202,436	4.08			
1858	4,790,388	149,915	3.13			
1859	5,448,372	196,751	3.61			
1860	4,626,420	163,027	3.52			
	30,229,328	1,019,961	3.37			
1861	3,970,320	146,464	3.69			
1862	4,311,960	195,485	4.53			
1863	3,394,896	158,852	4.68			
1864	3,461,832	162,071	4.68			
1865	1,899,072	87,954	4.63			
1866	3,332,724	135,253	4.06			
1867	2,614,824	128,537	4.91			
1868	2,546,112	117,172	4.60			
1869		77,405		$1,152		
1870		76,459		8,520		
		1,285,652				
1871		56,891		2,479		
1872		80,014		2,677	$28,168	$30,845
1873		128,925				
1874		88,379		714	57,895	58,609
1875		109,368		3,586	29,563	33,149
1876		72,935		2,534	26,079	28,613
1877		61,205		36,302	54,663	90,965
1878	1,403,724	67,111	4.78	6,212	24,638	30,850
1879	1,005,984	48,169	4.79	134,728	27,958	162,686
1880	1,293,360	59,806	4.63	26,820	28,439	55,259
		772,803				
1881	2,364,528	110,059	4.65	109,007	89,761	198,768
1882	1,831,164	78,976	4.31	19,082	30,592	49,674
1883	1,939,500	78,911	4.07	27,826	4,907	32,733
1884	1,530,432	57,443	3.75			68,764
1885	1,821,432	67,572	3.71			224,212
1886	1,520,688	45,551	2.99			44,735
1887	1,766,592	47,679	2.69			67,154
1888	1,893,816	46,210	2.44			7,579
1889	968,976	26,624	2.74			93,888
1890	757,428	27,191	3.59			113,101
	16,394,556	586,216	3.58			900,608
1891	572,880	20,808	3.63			83,325
1892	841,236	31,418	3.73			78,048
1893	2,113,764	79,396	3.76			15,115
1894	1,831,716	56,156	3.07			127,282
1895	809,328	22,993	2.84			118,873
1896	959,820	30,609	3.19			90,909
1897	797,184	27,599	3.46			22,368
1898	1,159,248	38,158	3.29			98,504
1899	1,514,604	51,599	3.41			55,900
1900	1,762,320	70,857	4.02			30,191
	12,362,100	379,593	3.07			720,575
1901	2,186,352	83,599	3.82			55,574
1902	2,007,612	56,383	2.81			106,112
1903	3,452,352	115,400	3.34			64,220
1904	2,475,504	69,053	2.79			69,317
1905	2,383,404	76,719	3.22			63,367
1906	1,658,652	50,651	3.05			111,945
1907	2,108,064	70,854	3.36			93,090
1908	2,543,904	98,425	3.9			78,102

[a] Only values are given in reports.

TABLE VII.—*Imports and exports of beeswax into the United States, 1851–1908.*

Year ending June 30—	Imports.			Exports.		
	Pounds.	Value.	Average price, in cents.	Pounds.	Value.	Average price, in cents.
1851				[b] 415,923	[b] $122,835	[b] 29.5
1852				[b] 326,368	[b] 91,499	[b] 28.0
1853				[b] 376,693	[b] 113,602	[b] 30.2
1854				[b] 327,554	[b] 87,140	[b] 26.6
1855				[b] 257,415	[b] 69,905	[b] 27.2
1856				[b] 270,320	[b] 74,005	[b] 27.4
1857				[b] 315,378	[b] 91,983	[b] 29.2
1858				[b] 366,246	[b] 85,926	[b] 23.5
1859				[b] 290,374	[b] 94,850	[b] 32.7
1860				[b] 362,474	[b] 131,803	[b] 36.4
				[b] 3,308,745	[b] 963,548	29.1
1861				[b] 270,425	[b] 94,495	[b] 34.9
1862				[b] 142,312	[b] 47,383	[b] 33.3
1863				[b] 258,901	[b] 80,899	[b] 31.2
1864	[a] 54,087	[a] $13,667	[a] 25.3	[b] 341,458	[b] 170,418	[b] 49.9
1865	20,899	6,414	30.7	[b] 338,776	[b] 261,381	[b] 77.2
1866	[a] 23,900	[a] 10,420	[a] 43.6	[b] 272,987	[b] 130,650	[b] 47.9
1867	25,617	5,450	21.3	[b] 253,065	[b] 96,282	[b] 38.0
1868		5,609		[b] 826,887	[b] 255,365	[b] 30.9
1869					189,396	
1870		[a] 19,897		[b] 346,668	[b] 137,443	[b] 39.6
					[b] 1,463,712	
1871		[a] 16,817		[b] 365,195	[b] 113,070	[b] 31.0
1872		[a] 20,196		[b] 446,474	[b] 126,130	[b] 28.3
1873		14,661		[b] 374,486	[b] 118,053	[b] 31.5
1874		7,918		[b] 342,068	[b] 113,800	[b] 33.3
1875		15,400		[b] 353,425	[b] 96,578	[b] 27.3
1876		14,668		[b] 218,610	[b] 69,127	[b] 31.6
1877		[a] 16,844		[b] 276,891	[b] 84,461	[b] 30.5
1878		13,302		[b] 326,613	[b] 95,074	[b] 29.1
1879		[a] 15,861		168,745	45,823	27.2
1880		[a] 2,766		193,217	48,880	25.3
		[a] 138,433		3,065,724	910,996	29.7
1881		[a] 6,733		164,090	40,203	24.5
1882		[a] 5,312		124,227	32,325	26.0
1883	168,879	41,681	24.7	59,455	17,604	29.6
1884	48,123	9,323	19.4	51,748	16,042	31.0
1885	91,754	21,211	23.1	30,877	9,758	31.6
1886	26,546	5,718	21.5	136,179	36,626	26.9
1887	10,843	2,371	21.9	90,350	24,997	27.7
1888	51,702	9,411	18.2	78,070	20,554	26.3
1889	75,951	11,773	15.5	99,917	23,918	23.9
1890	126,319	20,282	16.1	171,391	19,727	11.5
		133,815		1,006,304	241,754	24.0
1891	379,135	80,485	21.2	120,548	30,027	24.9
1892	271,068	65,487	24.2	127,470	31,898	25.0
1893	248,000	62,024	25.0	77,434	22,048	28.5
1894	318,660	80,024	25.1	469,763	118,093	25.1
1895	288,001	78,776	27.4	309,212	90,875	29.4
1896	273,464	75,970	27.8	222,612	65,844	29.6
1897	174,017	43,339	24.9	195,048	56,462	28.9
1898	272,097	72,473	26.6	151,094	41,827	27.7
1899	452,016	109,957	24.3	152,494	41,916	27.5
1900	213,813	51,526	24.1	319,379	91,913	28.8
	2,890,271	720,061	24.9	2,145,054	590,903	27.5
1901	213,773	55,884	26.1	140,276	39,464	28.1
1902	408,706	115,937	28.4	125,283	36,541	29.2
1903	488,576	127,220	26.0	70,811	21,337	30.0
1904	425,168	116,878	27.5	55,631	16,545	30.0
1905	373,569	101,121	27.1	85,406	24,966	29.2
1906	587,617	168,014	28.6	101,726	29,894	29.4
1907	917,088	264,637	28.9	117,169	36,392	31.0
1908	671,526	194,769	29.0			

[a] Including manufactured wax.
[b] Stated simply as "wax," and including wax of all kinds, as well as beeswax.

The following figures give additional evidence of the magnitude of the industry:

Bee keepers' associations (estimated)	100
Number listed in office of Bureau [a]	86
Journals devoted to bee keeping [b]	3
Breeders of queens actually recorded (not including duplicates)	[c] 164
Breeders of Italians	146
Breeders of Carniolans	37
Breeders of Caucasians	35
Breeders of Cyprians	6
Breeders of "Holylands"	5
Breeders of Banats	6

In addition there are several large factories devoted either entirely or in large part to the manufacture of supplies for use in the apiary.

VALUE OF THE HONEY BEE AS A POLLENIZING AGENT.

The honey bee is of great value as a pollenizing agent, and in estimating the value of the industry in adding to the resources of the country this phase of the subject must be included. Other insects, of course, aid in this way, but the honey bee occupies a peculiar position in a consideration of this subject.

Waite [d] mentions a large number of species of insects which visit pear blossoms, but says: "The common honey bee is the most regular and important abundant visitor, and probably does more good than any other species." Müller,[e] in his very comprehensive study of the fertilization of flowers, summarizes his results as shown in Table VIII.

TABLE VIII.—*Fertilization of plants by insects.*[f]

	In Low Germany.			On the Alps generally.			Above the limit of trees.		
	Species of insects.	Visits observed.	Per cent of total.	Species of insects.	Visits observed.	Per cent of total.	Species of insects.	Visits observed.	Per cent of total.
Coleoptera	129	469	8.96	83	337	5.90	33	134	4.82
Diptera	253	1,598	30.55	348	1,856	32.49	210	930	33.46
Hymenoptera	368	2,750	52.57	183	1,382	24.20	88	519	18.68
(Apidæ)	(205)	(2,191)	41.31	(120)	(1,141)	20.00	(49)	(402)	14.46
Lepidoptera	79	365	6.98	220	2,122	37.15	148	1,190	42.83
Other insects	14	49	.94	7	15	.26	3	6	.21
Total	843	6,231	....	841	5,712	....	482	2,779	....

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[a] Several of the State and county organizations are affiliated with the National Bee Keeper's Association.

[b] Gleanings in Bee Culture, Medina, Ohio, founded 1873. Bee-Keeper's Review, Flint, Mich., founded 1888. American Bee Journal, Chicago, Ill., founded 1861.

[c] The total number is probably twice this.

[d] Waite, M. B., 1895.—The Pollination of Pear Flowers. Bulletin No. 5, Division of Vegetable Pathology, U. S. Dept. of Agriculture.

[e] Müller, H., 1883.—The Fertilization of Flowers. Trans. by Thompson, London.

[f] From Müller, pp. 596–597.

In Table VIII the entire family of the Apidæ is credited with 41.31 per cent of the visits, but in the text Müller frequently refers to the fact that on some plants the honey bee far outnumbers all other insects. He speaks of the honey bees and the bumblebees of the genus Bombus as playing "by far the most important part in fertilizing our [German] indigenous flowers." On the other hand, Britton and Viereck [a] attempt to show that the honey bee is not so important as has generally been claimed by horticulturists and entomologists. They find that "honey bees were exceedingly scarce in comparison with other species of Hymenoptera—or in fact with other insects." From collections made from flowers in 1904 at the experiment station at New Haven and in 1905 at Branford, Conn., the following records were made:

	Gooseberry.	Red currant.	Black currant.	Wild plum.	Japan plum.	Sweet cherry.	Peach.	Apple.	Pear.	Quince.	Blackberry.	Raspberry.	Strawberry.
Hymenoptera	46	28	15	5	23	29	8	32	17	22	8	13	4
Apis mellifera						1	1	1		1	1		
Diptera	19	27	7	8	16	4		16	9	7			
Coleoptera	4	2	1	2	5	4		3	3	1			2
Hemiptera	3	2						1					
Total number of specimens	72	59	23	15	44	37	8	52	29	30	8	13	6

> It seems fair to assume that on account of their great numbers the small bees belonging to the Halictidæ and the Andrenidæ are more important agents in carrying pollen than has been supposed, and in the vicinity of New Haven during the seasons of 1904 and 1905 were of far greater benefit in pollinating the flowers of the plants from which they were collected than were the honey bees.

Earlier in the paper they say: "It is not known to the writers that bees are kept in the immediate vicinity of the experiment station; there are several hives less than 2 miles away. Wild honey bees are probably not very abundant so near the city."

There are several facts which should be taken into consideration in connection with this paper—facts not mentioned by the authors. In the first place, comparatively few honey bees are kept in the part of Connecticut around New Haven. Furthermore, a scourge of bee disease is said to have decimated the bees of Connecticut some years ago, and doubtless this decreased the number of bees in a wild state as much as it is known to have done in the case of bees in hives. No disease is now recorded from the vicinity of New Haven, but it may still be there unreported, it being found in many parts of the State. Further, in the vicinity of cities, bees are generally less prevalent than in the country. The principal point which should be considered, however, is that the winter of 1903–4, just before these counts were made, was exceedingly severe, and 75 per cent of the colonies of honey bees in New England are reported to have died. Honey bees do not hibernate, and long-protracted cold weather is detrimental to them. Taking these facts into consideration, it is not so strange that the honey bee played a minor part in pollinating the flowers in the cases investigated.

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[a] Britton and Viereck, 1906.—Insects Collected from the Flowers of Fruit Trees and Plants. Fifth Report of the Connecticut State Entomologist for the Year 1905, New Haven, Conn.

While in the particular cases observed by these authors the honey bee was of little value as a pollenizer, the ease with which an enormous number of honey bees could be brought to the aid of the orchardist places this species in a class by itself. Estimating the population of a colony of bees as low as 10,000 in early spring, it may easily be seen how readily the orchardist may insure pollination by carrying a few colonies of bees to the orchard, provided of course that the weather is such that bees can fly while the trees are in bloom. Under adverse conditions in winter the other insects may be so decimated that they are few in number, but while honey bees may also be killed off in winter, there are means of protecting them, which is not the case with the purely wild species.

Fruit growers as a rule recognize the value of the honey bee to their industry. Taking into consideration the insurance of pollination by transporting colonies of bees to the places where their services are needed, it is safe to say that the indirect benefit of the bee-keeping industry annually adds to the resources of the country considerably more than the amount received from the sale of honey and wax.

PRESENT SOURCES OF LOSS.

There are several sources of great loss to bee keepers which might be eliminated to a large extent by careful manipulation, but there is much work which must be done before bee keepers are able to overcome all these difficulties. Certain losses are expected regularly, and, while some do their utmost to overcome them, an annual loss must figure in their calculations.

Swarming.—The average bee keeper loses many of the swarms which issue from his hives, and these escaping swarms may well be valued at a high figure. By careful manipulation and the use of large hives swarming may be largely controlled, but among the majority of bee keepers too little attention is given to this phase of the work and nothing is done until the swarm actually issues. In the production of comb honey smaller hives are generally used, and the control of swarming becomes more difficult. It is doubtless true that swarms aggregating in value $1,000,000 are lost every year. This loss may be considerably reduced.

The greatest obstacle in the control of swarming is the fact that the activities bringing on swarming are so little understood. This phenomenon represents the bee's natural method of increasing the number of colonies, and it may be attributed to instinct. This, however, does not explain what factors induce the bees to swarm or what their activities are previous to swarming. When the behavior of the bees before and during swarming is better understood, we may have greater hope of a method of control.

Winter losses.—The losses in winter are considerable, due largely to starvation, dampness, too long a time without a cleansing flight, or extreme cold weather. By wintering bees in cellars in the North this loss may be considerably reduced, but while much has been written on this subject the general loss to northern bee keepers is probably at least 10 per cent every winter. An even temperature of about 45° F. and a dry atmosphere are considered best, and the best method of obtaining these conditions is an individual problem.

Where bee keepers do not pay any attention to the selection of their best stock for breeding purposes, the loss of 10 per cent or more of their colonies in winter must not be looked on as a total loss, for generally the poorest colonies succumb. In the southwestern part of the United States the winter problem can be said not to exist in the way it does in the North, and, as a result, a large part of the bees kept there are of poor stock, vastly inferior in many cases to equally neglected stock in portions of the country where winters are severe.

On the other hand, in these warmer portions of the country it is necessary to leave much heavier stores of honey in the hives to carry the colonies over from one season of activity to the next, so that "wintering" is very expensive. It has been suggested seriously that colonies be placed in cold storage for several months to save this heavy consumption.

"Winter loss" is in many cases caused by disease, which so weakens the colony during the summer that it is not able to survive the winter. In such cases the bee keeper is usually ignorant of disease.

Waste of wax.—No other manipulation of the apiary is so primitive as wax extraction and nowhere is there more room for improvement. As every bee keeper knows, it is difficult to remove wax from the comb, particularly in the case of old combs which have been used for brood rearing for years. The amount of wax wasted every year by inadequate methods of extraction amounts to thousands of dollars annually. In most cases over 10 per cent of the wax remains in the "slumgum," and even by careful work 5 per cent is left. By repeated rendering, the amount may be reduced, but the time necessary for this usually makes it unprofitable.

With the advent of the movable-frame hive and honey extractor it became orthodox to continue the use of combs year after year. The invention of methods making this possible was of such great benefit to the apicultural industry that it may almost be said that without it there would be no industry. At the same time it may be that bee keepers have formed the habit of using their combs in this way, and in consequence are losing wax. It must not be overlooked that it is part of the life activity of bees to build wax, and in working bees to get the maximum financial return from them it may be desirable to allow them to spend some energy on wax production. For example, immediately after swarming, under natural conditions, bees secrete a large amount of wax; they also, of course, build wax at other times, but there is much more of a tendency then than at any other period of their activity. There is good reason to believe, also, that at the time specified the amount of honey consumed in building a pound of wax is less than at any other time. With wax worth so much more per pound than honey, it would seem to be desirable in some cases to take advantage of the wax-building ability of bees.

In rendering wax from comb the usual procedure is to squeeze the combs in a press while hot. With but few exceptions, this is the only method used. Since this takes too long, and especially since all the wax can not possibly be removed, it would be wise to look for some other method. A better method would not only mean greater profits, but would be a gigantic step in advance in bee-disease eradication.

The loss due to inadequate extraction does not, of course, include the enormous loss from wax which is thrown away or which is allowed to be destroyed by wax moths for lack of fumigation.

Enemies.—When it is considered that bees live in a large community and seemingly present an excellent opportunity for the intrusion of parasitic forms and predaceous animals, it is a matter of surprise that they are so free from this source of loss.

The wax moths (*Galleria mellonella* L. and *Achroia grisella* Fab.) rarely trouble thrifty colonies, and therefore are not dreaded by progressive bee keepers in the colonies; they do, however, often destroy stored combs.

Diseases.—From the standpoint of present need there is no question in apiculture which at all compares in importance with the control of bee diseases. There are now recognized two distinct brood diseases which are contagious and which annually cause enormous losses to those engaged in the industry. There is reason, too, to believe that these diseases are spreading to new localities at a rapid rate, and unless vigorous steps are taken there can be no doubt that in a few years they will be distributed to every part of the United States.

The apathy of bee keepers, as a class, to these scourges is remarkable, in view of the fact that information is available which should point out the dangers now incurred by inadequate efforts toward the control of these pests, or in most cases by no effort at all.

As an example of the annual loss from this source, the following figures, furnished the author by Mr. Charles Stewart, one of the State inspectors, from the statistics of the New York department of agriculture, are of value. These figures are based on the actual number of colonies suffering from European foul brood which were destroyed or ordered destroyed by the inspectors of apiaries and do not represent the decreased returns from colonies not treated or from those affected with disease and treated. This epidemic started about 1897. The decrease in annual loss will be discussed later.

Previous to 1899	$39,383
During 1899	25,420
1900	20,289
1901	10,853
1902	5,860
During 1903	$4,741
1904	2,220
1905	1,725
Total	110,491

In the majority of cases it is absolutely impossible to estimate the losses, because so little is known of the actual territory covered; but if a loss of $25,000 is possible in a few counties in one State and there are many areas much larger where disease is equally epidemic, the loss may well be estimated at $2,000,000 annually.

The figures of the epidemic in New York offer an excellent example of what may be done in eradicating a contagious disease. Unfortunately that State had no means for taking up an extermination of European foul brood as soon as it appeared, but steps were taken to begin inspection as soon as such an innovation could be introduced. By hard work on the part of four competent inspectors the annual loss was rapidly reduced. The same results may be obtained anywhere by the employment of competent men to do the work, so that from a rapidly spreading epidemic, threatening the bee industry, the situation is changed until the disease becomes not so much a scourge as an inconvenience. In the case in question there can be no doubt that the annual loss would soon have reached $50,000 or that the industry would have been practically destroyed had no State aid been given just when it was.

Not only is inspection of value in a case of this kind, but it is of inestimable value in making possible the stopping of an epidemic in its early stages. To continue with New York as an example, the same disease, European foul brood, has since broken out in three other localities, but the force of inspectors went to work at once and there is little danger of serious trouble. It is safe to say that the value of inspection in this State is nearly equal to the annual value of the industry in the State. The value of the honey and wax produced in New York in 1899—the year State inspection was instituted—is given as $352,795 in the census for 1900. This is obviously too low.

Several States have passed laws for the control of these diseases and, in the majority of cases, the results are as good as can be expected. The laws are not always all that could be desired. Table IX shows the States having inspection and the force at work.

TABLE IX.—*Status of bee-disease inspection in the United States.*

State.	Method of inspection.	Number of inspectors.	Principal disease.	Authority.
California	County	15	American foul brood	State law.
Colorado	do	12	do	Do.
Idaho	Divisions of State.	2	do	Do.
Illinois	State	1	American foul brood and European foul brood.	State bee keepers' association. (No police power.)
Kansas	County	(?)	American foul brood	State law.
Michigan	State	1	American foul brood and European foul brood.	Do.
Minnesota	do	2(?)	American foul brood	Do.
Missouri	do	1	do	Do.
Nebraska	County	2	do	Do.
Nevada	do			(?)
New Mexico	do	1	American foul brood	Law against keeping diseased colonies.
New York	Divisions of State.	4	European foul brood and American foul brood.	State law.
Ohio	County	2	do	Do.
Oregon	do			(?)
Texas	Divisions of State.	4	American foul brood	State law.
Utah	County	4	do	Do.
Washington	do	1	do	Do.
Wisconsin	State	1	do	Do.

Other States are at work on this same question and it may be expected that within a few years the diseases will be controlled as much as is possible by inspection.

Badly proportioned distribution of apiaries.—A present source of loss to the industry as a whole is the fact that the available area for nectar gathering is not properly covered with apiaries; in some cases it is overstocked, but far more generally there is room for several times as many colonies. In pointing out the loss on this account it need scarcely be expected that a method for remedying the present conditions will immediately follow.

As apiculture advances, more and more of the available bee territory will be covered and, naturally, overstocking will be brought on in many cases. By natural growth of bee keeping the present lost nectar will probably be brought to the hives. Viewing the question, however, from the standpoint of the industry as a whole, it is desirable that this nectar be collected by bees under the management of intensive bee keepers—by men who can get the maximum crop from the bees. This can be brought about only by education of the men engaged in the work to the greatest possible proficiency. It can not be hoped that men owning but a few colonies will be sufficiently interested to carry on intensive apiculture. If, therefore, efforts are put forth to bring the industry to its highest point, they should be directed toward the making of specialists in larger numbers. Above all, there should be no ''booming'' of the industry, no effort to ''popularize'' it, for it is not desirable that everybody keep bees. Bee keeping requires careful work, and to get a financial profit is not possible in the majority of cases. To advocate bee keeping as a general avocation not only hurts reputable bee keepers but generally leads to grave disappointment on the part of those who are led into it by glowing accounts.

THE NEEDS AND POSSIBILITIES OF APICULTURE.

That there is room for growth in the bee-keeping industry admits of no doubt. The fact that honey for table use is a luxury rather than a necessity makes possible a great increase in marketing by the creation of a desire for it. This is recognized by those who are engaged in the building up of a local market for their product, for it is found that the amount of honey consumed in a community increases rapidly when honey is brought to its attention.

A large part of the honey put on the general market does not go into retail trade, but is used in manufacturing. This phase of the market is of relatively recent growth and, in spite of the fact that most bakers and confectioners pay a small price for honey, there is in this case also room for more. Several confectioners have stated to the author that they find it difficult to get enough honey in the general market for their own use.

In discussing the needs of the bee-keeping industry these may perhaps be best divided under three headings—scientific, economic, and educational. In naming them it does not follow that all are absolute necessities before the industry can reach its highest perfection, but there are many lines which should be taken up which, while not necessary, are very desirable in order that the men engaged in the industry may be well informed concerning the various phases of the science.

SCIENTIFIC NEEDS.

Statistical.—In order that honey and wax may come to hold a stable place in the market there should be available more detailed statistics as to the scope of the industry and, following that, properly timed crop reports, so that the products may sell for what they are worth.

Zoological.—In spite of all that has been written on races of bees, the subject is far from being completely exhausted. More reliable work should also be done on the anatomy and embryology of the bee.

Numerous papers and books have been written on these subjects, especially on anatomy, but they generally prove incorrect and unscientific when carefully studied. It is regrettable that too often pseudoscientists have been allowed to impose on the bee-keeping public by sending out publications purporting to be the results of research which are in reality compilations in large part, and the actual observations of the author are not based on a proper preparation for such work. The amount of work done on the physiology of the bee is indeed meager; the problem is a difficult one, but as technique is perfected such work should be taken up. The whole basis of practical apiculture is a knowledge of the behavior of the bee; without such knowledge there could be no good practical work. Probably no insect has been studied from this standpoint more than has the honeybee, but every new piece of work done simply points out new lines of work that are desirable.

Botanical.—Our knowledge of nectar-secreting plants now consists largely of random observations, usually for a limited locality, recorded in bee journals and books. Systematic work along this line, if done by competent observers, would give to the bee keeper the means of studying the possibilities of any locality as it can not now be done. More work is needed to give accurate information as to the part played by the honey bee in plant pollination, as well as data showing the present value of, and future possibilities in, that work.

Bacteriological.—The cause of one brood disease is now known,[a] but there is still a great deal of work to be done in the study of the bacteria of disease. This work is of the highest practical importance, for without a thorough knowledge of the organisms it is impossible to diagnose the more obscure samples, and only by a detailed study can information be gathered as to the amount of heat or disinfectant which must be used in combating disease.

Chemical.—Considerable work has been done on honey analysis, and a recent publication[b] of the Bureau of Chemistry of this Department is an excellent piece of work which lays the foundation of a good market for pure honey in making it possible to detect adulteration. In addition to what is already done, there should be a more detailed study of honeys from individual honey-plant sources.

ECONOMIC NEEDS.

There is or should be no sharp distinction between scientific and practical bee keeping. Practical bee keeping is but the application of discoveries made by scientific work. It is not always recognized, but it is nevertheless true, that careful systematic work on methods of wintering, production of the maximum crop of comb or extracted honey, or the like, is really scientific work on the behavior of the bee, and, if done properly, is just as truly scientific work as any that has been mentioned previously. Breeding of better bees and inspection for disease or for honey adulteration are but practical applications of scientific investigations.

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[a] White, Dr. G. F.—The Cause of American Foul Brood. Circular No. 94, Bureau of Entomology, U. S. Dept. of Agriculture, 4 pp., 1907.

[b] Browne, C. A., and Young, W. J.—Chemical Analysis and Composition of American Honeys, including a Microscopical Study of Honey Pollen. Bulletin No. 110, Bureau of Chemistry, U. S. Dept. of Agriculture, 93 pp., VI plates, 1908.

The question of breeding is economic and very important. It is doubtless a fact that at least three-fourths of the colonies of bees now found in the United States are not what they should be or what they would be if proper attention were paid to breeding. By requeening such colonies from good stock the annual output of honey would be enormously increased, provided, of course, that the improved stock were properly manipulated.

> At present the tendency among bee keepers is to accomplish by manipulation the things which would be attempted in breeding. Thus, instead of breeding for nonswarming bees, we have attempts at the construction of hives which provide environments conducive to nonswarming. Instead of breeding for prolificness we have trials at using two queens in one hive to get the same result. Good wintering qualities are replaced by extra care in wintering, and tongue length becomes less important by the use of alsike clover for pasturage in place of red clover, the nectar of which is largely lost to the honey bee. Activity in honey gathering is replaced by the keeping of a large number of colonies.
>
> As long as the bee-keeping field is not more completely filled, these methods of avoiding the breeding problem will be more or less successful. The time should come, however, and probably will, when bee keepers can no longer neglect this line of work.[a]

EDUCATIONAL NEEDS.

While the problems above enumerated represent a vast amount of work which must be done, the problem which entails the greatest amount of labor is the spread of information to the individual bee keepers who want it. Several agencies are now at work doing valuable service, among which may be mentioned the journals devoted to bee keeping, associations of bee keepers, the teaching of apiculture in some agricultural colleges, and the work of some experiment stations. The Bureau of Entomology aims to aid in the work. Most of the text-books on bee keeping are educational rather than records of personal investigation, for in large part they very properly draw from many sources and prepare the data for the use of the bee keepers.

First of all there must be an improvement in the methods of compiling the work done by others. The literature on bee keeping is so enormous that the average individual can not attempt to cover it, and to aid in this phase of the work this Bureau is arranging a bibliography of apicultural papers and books. This has been begun only recently, but it now contains about 8,000 titles and is growing rapidly. This bibliography is in conjunction with the files containing the results of investigations carried on in the Bureau, as well as synopses, translations, and notes on the work of others in various branches of the subject.

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[a] 1908. American Breeders' Association, Vol. IV, pp. 200–201.

The greatest difficulty encountered is the finding of the way to get in touch with the bee keepers to present to them the results of work. Naturally the bee journals are anxious to do the same thing to increase their subscription lists, and the associations to increase their membership. The Bureau of Entomology has recently tried, as an experiment, direct communication with all the bee keepers in Massachusetts and the results are highly satisfactory; so much so, in fact, that the same work is being carried on in two other States. The amount of time and work that is necessary, however, makes it impossible to carry out this work generally.

Under this heading comes also the education of the public to the use of honey. In most cases this must be done by the bee keeper in his own locality. The average amount of honey consumed per individual is now too small, and can be increased by some proper means of bringing it to the attention of the public.

When the situation is carefully studied, it becomes evident that the possible annual crop of honey and wax is several times greater than the present crop. If bee diseases can be properly controlled and good information be properly disseminated, there is good reason for considering the future of commercial apiculture as very hopeful. The industry of apiculture depends on commercial bee keepers and not on the bee keeper with small interests.

SUMMARY.

The growth of apiculture during the past half century has been remarkable and its present extent is little understood.

Bee keeping is usually not the sole occupation, but is a side line.

There are in the United States over 700,000 bee keepers producing annually $20,000,000 worth of honey and $2,000,000 worth of beeswax.

The average number of colonies per bee keeper is less than 6.

The annual importation of honey amounts to about 2,500,000 pounds, and that of wax to about 700,000 pounds.

The honey bee probably does more good to American agriculture as a pollenizing agent than as a honey producer.

The present sources of loss are due to swarming, winter losses, waste of wax, enemies, disease, and wasted nectar. Of these sources of loss, contagious diseases are the greatest and demand attention.

There is much need of further investigations in apiculture, and a few of the desirable lines of work are pointed out. The work to be done is grouped in three classes—scientific, economic, and educational.

Bee keeping as an industry is benefited only by the making of expert bee keepers financially interested in the business. The persons interested but little are a serious detriment to the industry, especially in regions where bee diseases exist.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 75, Part VII.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

BEE KEEPING IN MASSACHUSETTS.

BY

BURTON N. GATES,
Expert in Apiculture.

ISSUED MAY 24, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

206499

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U. S. D. A., B. E. Bul. 75, Part VII. Issued May 24, 1909.

MISCELLANEOUS PAPERS ON APICULTURE.

BEE KEEPING IN MASSACHUSETTS.

By Burton N. Gates,
Expert in Apiculture.

HISTORICAL SKETCH.

When, in 1620, the Pilgrims landed at Plymouth, this country knew no bees; the Indians in their languages had no equivalents for bee, honey, or wax. In Elliot's remarkable translation of the Bible he was obliged to use the English word for honey, with sometimes an Indian termination. Scarcely, however, had churches been erected, scarcely were clearings made in the wilderness for growing agricultural necessities, when the settlers turned their attention to securing honey bees from England. That such remarkably early trans-Atlantic shipments of bees were successful there can be no doubt. Josselyn, who visited New England twice, once in 1638 and again in 1663, speaks of " the honey-bee, which are carried over by the English and thrive there exceedingly," [a] but he does not tell when the first attempts to secure bees were made. Belknap,[b] however, wrote " that the first person who brought a hive of bees to this country [New England] was rewarded with a grant of land; but the person's name, or the place where the land lay, to whom the grant was made, I have not been able to learn." Unfortunately the records of the Colonies were not available to Belknap.

Newbury, a coast town north of Boston, was established in 1635. There the first effort to promote bee keeping in the New World was made. Furthermore, the importance of the industry was of municipal moment to the extent of holding out to one John Eales, who was then living in what is now Hingham, Mass., an inducement to come to Newbury for the purpose of teaching the settlers how to make hives and to care for bees. In August, 1644, Eales came "to one John Davis a Renter of a farm with ye expectation of his doing service which the Towne was not acquainted with."[a] Apparently, however, John Eales was not, financially or otherwise, a success. He was later arrested and put in jail in Ipswich, according to the record, and, on May 14, 1645, "It is conceived John Eales should be placed in some convenient place where he may be implied in his trade of bee-hive making, etc.; & ye town of Newbury to make up what his work wanteth of defraying ye charge of his livelyhoode."[b]

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[a] Josselyn, John. 1675. An Account of Two Voyages to New England. p. 120. Second edition. London. " The second edition is the first, with a new title page merely."—Sabin. Reprinted in Massachusetts Historical Society Collections, Vol. III, third series, p. 292, and by William Veazie, Boston, 1865.

[b] Belknap, Jeremy. 1792. A Discourse Intended to Commemorate the Discovery of America * * * to which are added, four dissertations * * * 3. On the Question, Whether the Honey-bee is a Native of America? * * * Boston, Belknap & Hall. 132 pages.

There can be little doubt that John Eales is the man to whom Belknap refers and to whom credit is due as the earliest bee keeper in the colonies.[c]

Further convincing evidence of the very early introduction of bees into New England is the date of their importation which Haydn[d] gives. According to this author, "bees were introduced into Boston, New England, in 1670, and have since spread over the continent." The source of his information is not given, but it is probably in some of the port records and can not refer to the first importation.

From these early times until more than a century later little or nothing is known of bee keeping in the State. In fact, during this epoch apiculture in the Old World was not well developed. It was not until the middle of the eighteenth century that writings on bees began to appear in Europe in any considerable number. Bees were receiving some attention in Massachusetts at this time, as is shown by a letter of a father to his son, dated, "Sutton [Massachusetts] June the 2d, 1788."[a] Besides speaking of sending to his son some homespun clothes the father adds, "as for news we have no grate to rite to you our bees have swormed yesterday and they flew of today."

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[a] Massachusetts Archives, Vol. L, pp. 4–5. [Manuscripts in the State House, Boston.]

[b] 1853. Records of the Governor and Company of the Massachusetts Bay in New England. Boston. Vol. 2, p. 101. [Period covered, 1642–1649.] John Eales was "Freeman made att the Generall Court, May 14, 1634." Ibid., Vol. 1, p. 369.

[c] See also: Adams, George W. 1906. Massachusetts Bee Keeping in 1644. American Bee Keeper, Vol. XVI, pp: 280–281.

Gerstäcker, A. 1862. Über die geographische Verbreitung und die Abänderungen der Honigbiene nebst Bemerkungen über die Ausländischen Honigbienen der alten Welt. (Zur XI. Wanderversammlung Deutsche Bienenwirthe zu Potsdam am 17, 18, und 19 September, 1862.) Potsdam. According to Von Buttel-Reepen this paper was given as "a card of admission" to those attending the Potsdam meeting. It has apparently become lost, excepting one copy from which Von Buttel-Reepen reprinted it as a part of his paper, "Apistica."

Von Buttel-Reepen, Dr. H. 1906. Apistica. Beiträge zur Systematik, Biologie, sowie zur geschichtlichen und geographischen Verbreitung der Honigbiene (*Apis mellifica* L.), ihrer Varietäten und der übrigen Apis-arten. Mittheilungen aus dem Zoologischen Museum zu Berlin, III, Heft 2, 8 fig., pp. IV+121–201. Issued also as a separate.

[d] Haydn, Joseph. 1904. Haydn's Dictionary of Dates and Universal Information, 23d edition. New York. Also other editions.

New England is reputed to have suffered severely from attacks of bee moths in the early part of the nineteenth century. There appears to have been a period of general devastation by this enemy from about 1800 to 1850. It handicapped the industry considerably, and, according to some, completely wiped it out in certain localities. Writing from Greenfield in 1853, L. L. Langstroth says:[b] "The present condition of practical bee keeping in this country [meaning the whole of New England and New York] is known to be deplorably low. From the great mass of agriculturalists * * * it receives not the slightest attention." There is room for considerable doubt, however, whether the moth was the primary cause of this devastation, as is explained below under the headings, "Enemies" and "Disease."

At the middle of the nineteenth century Langstroth, who had been experimenting for several years, brought out his invention, the movable-frame hive. As is explained under the head of "Hives," this revolutionized the industry; at that time modern bee keeping began.

Considering the very early date of the first introduction of bees to what is now Massachusetts, and that from this locality as a center much of the present-day bee keeping[c] spread westward with the home seekers, it is not a little surprising to discover so few extensive bee keepers in Massachusetts, while there are many in New York and Vermont. Compensating, however, for the lack of extensive bee keepers, there is a vast number of small apiaries; their number in proportion to the territory is probably greater than in any other State in the Union. There are at least 2,100[d] who derive some profit from their bees. Were these 2,100 to keep twenty-five colonies each and were their apiaries properly distributed over the State, there might not be forage enough to support them; but such is far from reality. The average is only five and a half colonies per bee keeper, which is evidently too small. In this is a key to the bee-keeping situation of the State; if the resources are to be fully utilized, more bees must be kept, not by more bee keepers, for there are too many small ones at present, but by several hundred proficient and energetic bee men properly distributed.

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[a] A photograph of this letter is in the possession of the writer.

[b] Langstroth, L. L. 1853. Langstroth on the Hive and the Honey-Bee, a Bee-Keeper's Manual. Northampton. First edition.

[c] The details of the present status of bee keeping in this paper are based upon the returns from a series of questions sent to every known bee keeper in Massachusetts. The method of securing the statistics was described in the author's paper read before the Association of Economic Entomologists, Baltimore, Md., December 29, 1908. This paper is published in the Journal of Economic Entomology, Vol. II, No. 2, pp. 117–120, April, 1909.

[d] By actual count, the recorded bee keepers for Massachusetts number 2,127. This exceeds the number recorded in the 1900 census by 328, which, considering that the author's work was accomplished through mail while the federal census is the result of a house-to-house canvass, suggests a deficiency in the figures of the federal census reports. Of the 2,127, 1,050 reported.

EXPERIENCE OF BEE KEEPERS IN MASSACHUSETTS.

Although there are too few bees kept, it is interesting to ascertain how experienced the Massachusetts bee keepers now are. In order to gain this information, a question, "How long have you kept bees?" was included in the list of questions circulated throughout the State. By thus knowing the length of time these men have been keeping bees, some idea of their proficiency may be reached. Of those who reported to the author, 38 per cent have had less than five years' experience and must consequently be classed as amateurs. While this array of amateurs, at first glance, appears high, it becomes more significant upon considering that 32 per cent, having successfully passed their apprenticeship, report from five to fifteen years' experience, or, in other words, have persisted and succeeded in bee keeping. On the other hand, roughly estimating, 50 per cent of the bee keepers who undertake this branch of agriculture discontinue it within their first five years' trial. This is not due to lack of possibilities in the bee-keeping industry, but must be attributed in a large measure to sensational presentation, in the popular press and elsewhere, of the ease of managing and the huge profits to be derived from bees. This overstimulation of the bee industry is a positive detriment to the bee-keeping interests. The number of persons who have taken and will take time for a proper study of bee culture is exceedingly limited in proportion to the number who undertake the work uninstructed. Consequently a 50 per cent weeding-out process during the first five years of attempted bee culture is a stroke of fortune for the industry. After fifteen years' experience, and before the twenty-five-year mark of service is passed, there is another falling off. The figures of this census show that 16 per cent of those reporting have kept bees from fifteen to twenty-five years, which, when it is considered that a bee keeper is well along in life by that time and often must necessarily relieve himself of care and work, is exactly what might be expected. No less interesting is the fact that 16 per cent continue after twenty-five years of service. These are the truly old bee keepers, many of whom remember Langstroth and his experimenting. While they may not be exactly up-to-date, they are to be respected for their persistency.

For purposes of comparison divide the State into two sections, the eastern section to include Worcester County and all other eastern counties save Barnstable County, which is not at all comparable either in population or from an agricultural point of view. If these two sections be contrasted, there will be found an obvious difference in their population. In the eastern section the cities and towns are large and the population concentrated, while in the western part the population is less dense and is thus far less influenced, on the whole, by large communities than the eastern section. It is in the large communities that bee keeping is usually promoted by supply houses and conventions, and it is there also that the majority who seek rural recreation along lines promoted by popular agricultural papers reside. Consequently, it is to be expected that the progress and stimulation of bee keeping, either as a recreation or an industry, should first be felt in and adjacent to these communities. This is precisely what is noticeable in Massachusetts. Back in the country of the more strictly rural section of the State, where population acquires but slowly the progressive impulses which are first launched in the larger communities, there are fewer new or amateur bee keepers than in the more thickly populated eastern section. In this western section the ratio of beginners to advanced bee keepers is as 30 to 70; while in the eastern section, where are found two bee-keepers' societies, the proportion of beginners is larger, with a possible ratio of 41 to 59. Aside from the influence of societies in the eastern section, supply houses have had a noticeable effect in stimulating popular interest and in promoting new and improved methods. As is pointed out above, sensational stimulation is unfavorable to the industry.

Table I.—*Proportion of amateurs to practiced bee keepers in the eastern and western sections of Massachusetts.*

Section of State.	Amateur bee keepers (5 years and less).		Practiced bee keepers.				Total number of bee keepers reporting.
			5 to 15 years.	15 to 25 years.	25 years and over.	Per cent.	
	Number.	*Per cent.*	*Number.*	*Number.*	*Number.*		
West of Worcester County	95	30	105	56	67	70	323
Worcester County and east, exclusive of Barnstable County	302	41	209	104	94	59	709
Barnstable County	3	....	8	6	1	....	18
Total for the State	400	38	322	166	162	62	1,050

NUMBER OF COLONIES PER BEE KEEPER.

There are but two bee keepers in the State who report more than 100 colonies, but several have nearly this number.

TABLE II.—*Location of Massachusetts' largest apiaries, as reported for 1906.*

County.	50 to 75 colonies.	75 to 100 colonies.	100 colonies and over.	County.	50 to 75 colonies.	75 to 100 colonies.	100 colonies and over.
Barnstable		1		Middlesex	4	1	
Essex	1			Plymouth	1		[a]2
Franklin		1					
Hampden	2			Total	9	3	2
Hampshire	1						

[a] One of these bee keepers writes that he increased from 55 to 133 colonies in 1906.

It is a peculiar fact that in Worcester County, where more bees are to be found than in any other county and where bee keeping is progressive, none reports 50 colonies and few have even 25. The two largest bee keepers in the State are located in Plymouth County. That there are so few large bee keepers in Massachusetts is due, in the writer's estimation, to the heretofore unrecognized ravages of disease. This is discussed elsewhere in this paper and in another publication of this Bureau.[a] In Middlesex County, for instance, where, so far as at present known, disease is not prevalent, the greatest number of large bee keepers is found and also the second greatest number of colonies.

DISTRIBUTION OF BEES IN MASSACHUSETTS.

In the eastern section, exclusive of Barnstable County, with its high ratio of novices, there are practically as many colonies of bees per bee keeper as in the western section. According to the figures for 1906, the following table presents the conditions:

TABLE III.—*Distribution of bees in Massachusetts.*

Section of State.	Spring.		Fall—Number of colonies.
	Number of colonies.	Colonies per bee keeper.	
West of Worcester County	1,760	5.4	2,530
Worcester County and east, exclusive of Barnstable County	3,897	5.5	5,595
Barnstable County	182	10.0	227
Total for the State	5,839	5.5	8,352

From the foregoing table it will be seen that the minimum number of colonies is in direct disproportion to the large number of bee keepers. The large population might account for this in the east, but this does not explain why the western bee keepers have not enlarged their apiaries, which without question should ultimately result. Again, disease is beginning to exert its influence, and a more general understanding of its nature and remedies should benefit the industry.

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[a] Gates, Burton N. 1908. Bee Diseases in Massachusetts. Bulletin No. 75, Part III, Bureau of Entomology, U. S. Department of Agriculture. Washington. Bul. 124, Mass. Agr. Exp. Station.

INCREASE IN NUMBER OF COLONIES.

The figures on increase which the writer obtained show an increase from 5,839 colonies in the spring to 8,350 colonies in the fall of 1906, a gain of 2,413 colonies, or 42 per cent. This is below normal and suggests the prevalence of bee diseases.

PRODUCTION OF HONEY AND WAX.

The subject of first importance to every bee keeper is the crop—How much honey and wax do the bees produce? Unfortunately, however, the majority do not go beyond this and ask how much ought the yield to be?

HONEY CROP.

The honey production of the State is little more than one-tenth what it might be. The markets demand much more honey than is produced in the State. As nearly as can be ascertained, some 80 tons of honey are annually harvested. Most of this is not shipped, but is consumed by the producer or his neighbors. There is no evidence that any honey is shipped out of the State; on the contrary, much comb and extracted honey is annually imported from Vermont, New York, and sometimes from the far West and South.[a]

Approximately 100 tons represents the total consumption during 1906. This consumption varies greatly from year to year, depending on the crop, as, for instance, in 1907, when scarcely any honey was obtainable in the market. The man who shipped 5½ tons from Vermont the previous year sent less than 1,000 pounds in 1907. None was received from New York, as in the previous year. But the estimate for 1906 of 100 tons is only one-half the amount estimated as consumed in 1904.[b] That year 200 tons, divided among the inhabitants of the State, would have allowed less than two tablespoonfuls per capita as a year's ration. Since then, however, the population has increased to more than 3,000,000,[a] and with the estimated crop of 100 tons in 1906 would have afforded each person less than one tablespoonful. Too little honey is available in Massachusetts. This is borne out by the common experience of those who try to buy extracted honey in convenient amounts or even in bulk for table use. The writer's experience is that it is almost impossible to purchase at retail a 60-pound can of good honey or even of a poorer grade at any price. As for being able to buy a gallon or a quart, it is impossible unless the purchaser is willing to pay a high price for a lot of small, fancy bottles, which may or may not contain good-grade honey. With these facts in mind, it is evident that much may be done to improve the retail trade in extracted honey. Comb honey, on the other hand, is usually available either from a producer or a retail store.

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[a] In 1906, 5½ tons came to Worcester from Vermont; from New York State 2½ tons. In Boston the imports, according to this authority, were approximately the same. It may be roughly estimated, therefore, that for 1906 at least 16 or at most 20 tons were received from points outside of the State. This information was kindly furnished the writer by Hon. W. H. Blodget, in a letter dated Worcester, Mass., April 11, 1908.

[b] Gates, Burton N., and Dr. C. F. Hodge. 1904. Bee Keeping; How to meet its dangers and difficulties. Mass. Crop Rept., vol. 17, No. 6, pp. 30–40, Boston. October. Also Fifty-second Ann. Rept. of the Secretary of the Mass. St. Bd. of Agric., pp. 411–426, Boston, 1905.

The crop in Massachusetts for 1906, as reported by something less than half the number of bee keepers recorded, was 145,257 pounds, approximately 73 tons; but since only a little over half the recorded bee keepers were heard from, 80 tons would be a conservative estimate, as is shown below. It is somewhat surprising that this study should show the largest recorded crop, and especially so in view of the fact that the investigation was carried on through the mails, while census data are obtained by personal canvass. This at least suggests that the census figures probably do not justly represent the industry.

Although 145,257 pounds of honey, of which 108,660 pounds was comb and 36,597 was extracted, is the heaviest crop recorded for the State, the product looks pitifully small when it is remembered that single apiarists in the West frequently produce in a season a fourth to a third more honey than Massachusetts' annual crop. If the actually recorded crop is divided by the number of colonies reported in the spring of 1906, this is an average of but 24 pounds per colony. Conservatively estimating from experience and reports of large practical apiarists in New York State and the West, the average yield, considering all classes of bee keepers, should be about 35 pounds. This would have made Massachusetts' crop, merely from the recorded number of colonies, spring count, 204,330 pounds, or 102 tons. Consequently the estimate of 80 tons, assumed for convenience, is safe. The question is, however, a larger one. The possibilities of the forage and the number of colonies which it would support is more vital than criticism of the present discrepancy. The writer has already stated[a] that Massachusetts can support approximately 40,000 colonies of bees. This number, producing an average of 35 pounds of honey to the colony, would supply 1,400,000 pounds, or 700 tons, of honey a year, contrasted with 73 tons. This crop would not be especially burdensome, and, divided among the people, each would have less than a half pound a year. Furthermore, there is no immediate danger of the production of any such amount.

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[a] Mass. Census, 1905, population 3,003,680.

TABLE IV.—*Honey and wax production reported in Massachusetts.*

Date.	Honey.	Wax.	Sources of data.
	Pounds.	*Pounds.*	
1839	...	1,196	U. S. Census Rept. for 1840.
1849	...	[a]59,508	U. S. Census Rept. for 1850.
1855	73.677	2,324.5	3d Ann. Rept. Sec. Mass. Bd. Agric. for 1856.
1859	59,125	3,289	U. S. Census Rept. for 1860.
1865	80,356	2,454	13th Ann. Rept. Sec. Mass. Bd. Agric. for 1866.
1869	25,299	1,195	U. S. Census Rept. for 1870.
1879	49,397	2,463	U. S. Census Rept. for 1880.
1889	90,929	1,690	U. S. Census Rept. for 1890.
1899	109,050	6,250	U. S. Census Rept. for 1900.
1906	[b]145,257	1,289	The author's census.

[a] Includes both honey and wax product.
[b] Extracted, 36,597 pounds; comb, 108,660 pounds.

WAX CROP.

It is customary for bee keepers to save their old combs from year to year before rendering them, which produces an annual variation in the product. Futhermore, outbreaks of bee diseases cause much more comb to be rendered. Severe winters, which frequently result in a loss of bees, usually produce a relative increase in the wax output the following year. It is therefore difficult to calculate a representative annual product of wax. The commercial importance of the wax crop, and the relative returns from it as compared with honey, are gradually becoming more and more realized; therefore, as the honey product increases it is to be expected that the wax output will proportionally increase. Table IV presents all the recorded information on wax production in Massachusetts.

SOURCES OF HONEY.

Too little attention is given the nectar-yielding flora, even among those who seek a livelihood in the production of honey. Although it is sometimes difficult to learn the sources from which bees get their stores, a bee keeper should have some knowledge of the honey plants of his locality and their honey value.

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[a] U. S. D. A., Bur. Ent. Bul. 75, Pt. III, p. 23. Allowing an average of 100 to 125 acres to support a colony of bees, based on experience of large bee keepers who maintain a series of outyards, and eliminating 500 square miles as probably unavailable for bee pasturage, there remain 7,814 square miles, or 5,000,960 acres, for forage in Massachusetts, which would support approximately 40,000 to 50,000 colonies of bees.

White clover.—Among the several clovers, white clover ranks first. It is found in nearly all quarters of the State, but flourishes best on limed or limestone soils, and is particularly abundant in the northern and western parts of the State. Just over the line in the Champlain Valley of Vermont the chief source of honey is white clover, which grows there in tangles and mats. White clover honey ranks high in the market; its color and flavor make it one of the finest of American honeys.

Alsike clover.—This is frequently sown for forage, and is becoming more and more renowned as a honey source. Under favorable conditions it yields not only a good quality of nectar, but large quantities of it. It rivals the red clover, on which bees work to a limited extent, but in which the vast stores of nectar are too deep in the flower tubes to be within reach of the bee's tongue. Alsike blooms with white clover and will bloom a second time when white clover has ceased, thus prolonging the honey flow from clover.

Red clover.—This is also a more or less continuous bloomer, which, inasmuch as the second flowering brings smaller, shorter-tubed heads, is somewhat accessible to bees.

Sweet clover.—There are two species, white and yellow, but neither is abundant in Massachusetts. It is a bountiful source of honey elsewhere, and may become so in this State.

Crimson clover.—As a honey plant this is of slight importance as far north as Massachusetts.

Golden-rod and asters.—These plants, as reported in this State, rank close to the clovers in nectar secretions. Both begin to flower in July and continue until frost. The early bloom, however, is not visited by bees to any extent, and it is not until September that the flow begins, when the hive takes on a characteristic strong and pleasant odor. The honey, though rather dark and thick, has a rich, aromatic flavor, which many people consider superior. In Massachusetts a marketable surplus is frequently taken in September.

Fruit bloom.—Apple, pear, cherry, plum, peach, etc., which are found in abundance throughout the State, are next in importance. Fruit bloom is the source of early stores upon which the colonies build up for the clover harvest. Insufficient numbers of bees at this season and unfavorable weather make it difficult to secure a surplus from this source, but the fortunate bee keeper who does secure a crop should realize that he has a superior product. The body is heavy, the color is clear and light (usually an amber), and the flow comes with a rush which insures handsome sections; but best of all is the exquisite aroma of the apple blossom, which places fruit-bloom honey in a class by itself.

Linden or basswood.—Cutting for lumber has tremendously reduced the number of basswood trees in the State. It was once generally distributed in the forests, but at present occurs largely only in the northern and western woods. This is doubtless the most valunable tree honey plant in Massachusetts and, together with its value for timber, merits cultivation. It makes a fine shade tree. The honey has quite a characteristic flavor and aroma, but requires to be well ripened before its delicious qualities are appreciable.

Buckwheat.—This is a famous honey plant in New York State and is reported from all counties of Massachusetts. Here, however, it is far less extensively grown than across the line. Some bee keepers say they plant small fields for the sake of their bees, but there is great doubt if the bees benefit materially by it except in cases of extreme scarcity of nectar. The honey is dark, with a brownish or purplish cast, a heavy body, and a strong, rank flavor to those who are accustomed to more delicate honeys, such as clover or fruit bloom. Many in New York State, however, often prefer buckwheat to clover honey. Especially if extracted, it usually commands a good price.

Wild raspberry and blackberry.—In the highland pastures wild raspberry and blackberry abound. The nectar flow is of long duration, beginning soon after fruit bloom has ceased, and thus is an important stimulant for the clover harvest to follow. Cultivated varieties are quite as valuable for forage as the wild species.

Sumac.—There are several species of sumac which are important honey sources, but which are greatly underestimated by the majority of bee keepers. They are free bloomers and flourish in nearly all parts of the State. Apparently, however, the nectar yield is somewhat erratic. The writer recalls seasons in Worcester County when bees paid no attention to the great heads of greenish flowers. Sumac honey, although not light, has a clear and firm body with a pleasant flavor.

Locust.—Like the basswoods, locusts have been largely cut from the woodlands. There are several species now found to a limited extent by roadsides and in pasture walls, where they are valuable forage for bees. In Colrain, Franklin County, one bee keeper attempted to cultivate locust for his bees, but met with no great returns for his efforts. Another bee keeper reports that locust is sporadic, yielding nectar only once in three years.

Maple.—A considerable number of bee keepers report that maple is a honey plant. It is, to be sure, one of the best sources of pollen in early spring, which doubtless has confused the bee keepers and caused them to report it as a honey plant. Swamp maple is especially valuable in early brood rearing. Maple is probably of less importance as a honey source than, for instance, the mints, strawberry, and milkweed, which were reported but a few times.

Clethra.—This is also known as black alder and sweet pepper bush, and is a valuable honey-secreting plant, largely confined to a belt paralleling the eastern coast, where it thrives in profusion. The aroma, a sweet smell, powerful and penetrating, may be perceived a long distance from the bush. Bees work upon it freely, and unquestionably produce considerable surplus honey, which is of good body and light color.

These, so far as bee keepers' observations afford, are the most prominent honey plants. Of the remaining list—each reported from one to fifteen times—milkweed, wild cherry, knotweed, dandelion, strawberry, chestnut, mints, gill-over-the-ground, and mustard are of most importance. No one of these taken alone is a source of surplus honey in Massachusetts, but all are important in the total yield. The writer has observed, in the spring when fruit trees are in bloom, a perceptible effect of dandelion nectar upon the delicate flavor of fruit-bloom honey, producing the characteristic bitterish taste.

Milkweed.—Where milkweed occurs in large quantities it is a valuable honey plant. In Berkshire County, Mr. Dewey, of Great Barrington, reports that milkweed is an important source of nectar.

One bee keeper in Hampshire County reports the Tartarian honeysuckle as important and very productive. Sunflowers are valuable but must occur in considerable numbers to make a perceptible difference in the crop.

Most of these plants are quite as important, so far as the economy of the bee is concerned, for their pollen as for their nectar. For instance, the willow and skunk cabbage, while they are reported as honey plants, are far more important as pollen yielders, because at their season of bloom pollen is scarce. The chestnut and, to a certain extent, the dandelion are more valuable for the pollen which they yield than for the honey.

THE MORE IMPORTANT HONEY PLANTS IN MASSACHUSETTS.

TABLE V.—*List of the more important honey plants in Massachusetts.*

[Arranged according to frequency of report.]

Name.	Times reported.
Clovers:	
White (*Trifolium repens*)	626
Alsike (*T. hybridum*)	37
Red (*T. pratense*)	7
Crimson (*T. incarnatum*)	3
Sweet (*Melilotus alba* and *M. officinalis*)	3
Yellow (*T. agrarium*)	1
	677
Golden-rods (*Solidago* spp.)	330
Asters (*Aster* spp.)	99
	429

TABLE V.—*List of the more important honey plants in Massachusetts*—Cont'd.

Name.	Times reported.
Fruit bloom (includes pear (*Pyrus* spp.), apple, cherry, peach, plum (*Prunus* spp.), etc...	337
Linden or basswood (*Tilia* spp.)	160
Buckwheat (*Fagopyrum* spp.)	144
	641
Raspberry (*Rubus* spp.)	103
Blackberry (*Rubus* spp.)	23
	126
Sumac (*Rhus* pp.)	89
Locust[a] (*Robinia* spp.)	43
Maple (*Acer* spp.)	36
Clethra (*Clethra alnifolia*)	24

[a] Does not yield every year; "Once in three years," one bee keeper says.

LIST OF PLANTS REPORTED RELATIVELY FEW TIMES.

(Reported from one to fifteen times.)

Alder (*Alnus* spp.).
Arnica, white flowering (*Arnica montana*).
Barberry (*Berberis* spp.).
Blueberry (*Vaccinium* spp.).
Burdock (*Arctium lappa*).
Buttercups (*Ranunculus* spp.).
Button bush (*Cephalanthus occidentalis*).
Cherry, wild (*Prunus* spp.).
Chestnut (*Castanea dentata* (marsh)).
Columbine (*Aquilegia canadensis*).
Cowpeas (*Vigna catjang*).
Cranberry (*Vaccinium* spp.).
Cucumber, cultivated (*Cucumis* spp.).
Cucumber, wild (*Micrampelis lobata*).
Dandelion (*Taraxacum* spp.).
Elderberry (*Sambucus* spp.).
Elm (*Ulmus* spp.).
Gentian, fringed (*Gentiana crinita*).
Geranium, wild (*Geranium* spp.).
Gill-over-the-ground (*Glecoma hederacea*).
Gooseberry, wild and cultivated (*Ribes* spp.).
Hickory (*Hicoria* spp.).
Honeysuckle, Tartarian[a] (*Lonicera tatarica*).
Horse chestnut (*Æsculus* spp.).
Huckleberry (*Gaylussacia* spp.).
Knotweed (*Polygonum* spp.).
Milkweed (*Asclepias* spp.).
Mints, catnip, etc. (*Mentha* spp.).
Mustards, wild (*Brassica* spp.).
New Jersey tea (*Ceanothus americanus*).
Radish (*Raphanus* spp.).
Shad bush, wild (*Amelanchier botryapium*).
Skunk cabbage (*Spathyema fœtida*).
Strawberry, wild and cultivated (*Fragaria* spp.).
Sunflowers (*Helianthus* spp.).
Syringa (*Philadelphus* spp.).
Thyme[b] (*Thymus serpyllum*).
Viburnum (*Viburnum* spp.).
Willow (*Salix* spp.).
Witch-hazel (*Hamamelis virginiana*).

PERIODS OF NECTAR SECRETIONS IN DIFFERENT LOCALITIES.

Through the courtesy of several bee keepers the writer is able to present with considerable detail the periods of nectar secretion of the more important honey plants in several sections of the State. It should be remembered, however, that the dates of nectar yielding must necessarily vary from year to year and at different elevations in the same territory; consequently the data here presented may be slightly at variance with other observations.

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[a] Reported of importance and very productive in Hampshire County.

[b] Jackson, Joseph J. 1894. Through Glade and Mead. Jackson (p. 293) lists it for Worcester County. It was also reported to the writer three times from Berkshire County.

BERKSHIRE REGION.

(Furnished by E. H. Dewey, of Great Barrington, Mass.)

Pussy willow, April 1 to 15. Pussy willow in sheltered places will bloom as early as the 15th of March and be visited by bees for pollen. Whether they get honey as early as that from this source I do not know. Just when pussy willow begins to yield honey I can not positively state, for bees work on it very early, but I have seen them with tongues extended in search of honey as early as the dates indicated.

Soft maple, April 1 to 8.

Hard maple, April 20 to May 5.

Fruit bloom, May 1 to 25.

Raspberry, June 5 to 30.

Locust, June 5 to 15.

Wild mustard. Wild mustard, I am told, appears about six weeks after cultivation. It is most frequently seen here from the middle of June to the 1st of July.

Clover, June 5 to July 25.

White sweet clover, July 10 to August 25.

Sumac, July 10 to 20.

Basswood, July 1 to 15.

Milkweed, July 5 to 20.

Chestnut, July 10 to 15.

Buckwheat, August 1 to 25.

Smartweed, September 5 to frost.

Brook sunflower (*Bidens lævis*), September 5 to —. It is fairly covered with bees. I have seen three or four working on a single blossom. Grows on low land and margins of water.

Golden-rod, August 20 to frost. One variety of golden-rod appears here the middle of August, but never secretes honey.

Asters, September 1 to frost.

Tag alders, September 1 to frost. In my immediate locality tag alders are not common, but can be found in swampy places a few miles from here.

CENTRAL REGION.

(Furnished by Dr. James B. Paige, Massachusetts Agricultural College, Amherst, Mass.)

Fruit bloom, May 12 to 30. Cherry, plum, and peach are the earliest. Apple lasts the longest.

Clover, June 10 to August 1.

European linden, June 15 to July 1.

Raspberry, June 6 or 7 to about June 20.

American linden, July 21 or 25 and lasts ten days to two weeks.

Buckwheat, latter part of July or August 1. Lasts nearly a month, according to quality of soil and location.

Golden-rod and asters, September 1, lasting until frost.

Smartweed, August 25 until frost. Does not appear to secrete after frost comes.

Wild clematis, July 25 to September 1. Cultivated variety (*Clematis paniculata*) blooms early in September, but I doubt if it secretes honey; it is sparingly visited for pollen.

Thoroughwort, ceases about 1st of September.

About the 1st of April we get soft maple, willow, skunk cabbage, alder and some elms, and cultivated plants, such as crocuses, etc., which, I suspect, supply more pollen than nectar.

CAPE COD REGION.[a]

(Furnished by Mr. Allen Latham, Norwich, Conn.[b])

Dandelion, in May.

Huckleberry, in late May.

Blackberry,[c] in late May.

White clover, in June and July.

Common locust (in Truro), June.

Sumac (*Rhus copallina*) (occasionally), in July.

White alder (*Clethra alnifolia*), July to August.

Fireweed (*Erechtites hieracifolia*), August to September.

Cut-leafed water hoarhound (*Lycopus americanus*), August to September.

Burr-marigold, August to September.

Pink knotweed, August to September.

Various golden-rods, August to September, especially *Solidago sempervirens*, a gigantic variety of golden-rod which thrives in the sand along the beach.

Various asters, like those which are common all over New England, September to October.

Cranberry, flourishes and blooms for a long period. This may yield nectar.

Strawberry, grows wild by the acre and the children and women carry bushels upon bushels of these berries home every June. Possibly in that region this plant yields nectar.

The beach plum is an old settler and is found all about the Cape whitening all the beach and dunes with its blooms in May. Whether the bees get any honey from that bloom I do not know.

Wild cherry, both the black or "rum" and the "choke," grow in abundance. As these yield practically nothing inland, I judge they furnish the bees no nectar there.

Listed in the order of their importance to the bee keeper:

1. Huckleberry.—Without this one could not be sure of a crop of honey oftener than every other year, and possibly not one year in three.

2–3. Hoarhound and fireweed.—Probably the hoarhound should rank ahead of fireweed.

4. Fall flowers, golden-rod and asters especially.

The fall flowers will always furnish a crop if the weather permits the bees to gather it, but too often the weather is foggy or high winds blow, or else it is too cold. I have never had such crops of fall honey here (Norwich, Conn.) as I have had down among those sand dunes, once in three or four years, strong colonies laying upward of a hundred pounds.

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[a] A good account of bee keeping in this region is found in the following paper: Miller, Arthur C. 1906. A Unique System. How an Ingenious School Teacher Harvests Crops of Honey from a Desert. American Bee Keeper, Vol. XVI, pp. 206–210, October. Illustrated.

[b] Mr. Latham specifies that the data relate to the "plants known to yield honey near Provincetown," the extreme end of Cape Cod, about 50 miles direct by sea from Boston and 25 miles from Plymouth.

[c] It is possible that blackberry is very important. I do not know its honey, and the flavor may be lost in the honey from huckleberry bloom.

5–6. White clover and Clethra, about equal.

7. Sumac.

RACES OF BEES.

Among the bees of Massachusetts are found representatives of those kept in all parts of the United States. They occur only in relative degrees of purity, due to the fact that young queens often mismate. "Hybrid" means any cross between recognized races, but more particularly and generally the cross between Italians and Germans.

ITALIAN BEES.

According to the data at hand, 594 bee keepers say they have Italians. This does not mean pure Italians in every instance, but it does indicate that practically half of the bee keepers who reported have Italians, a highly encouraging condition. Furthermore, 342 report that they have hybrids, which may almost universally be interpreted as a cross between Italians and Germans. By adding this to the number who report Italians, it makes 936, or about 80 per cent, of those reporting who have some Italian in their hives. This clearly demonstrates the popularity of the race.

There are several strains of Italians, such as "long-tongued," or "red-clover," and "golden," or "five-banded," and the like. Although these strains are all found in Massachusetts, data concerning them is not sufficient to decide their relative merits or popularity.

GERMAN BEES.

Pure German or black bees are exceedingly scarce. In the county of Worcester the writer has seen what he believed to have been the pure-blooded Germans; but these colonies are seldom met with. Although, as is shown in the table below, 196 persons report that they have German bees, there is as much or even more doubt that these are strictly pure as there is doubt that all of the Italians reported are pure. This race, at least in Massachusetts, is destined to be supplanted by the Italians, although some bee keepers still complain that their Italians are constantly being crossed with blacks.

CARNIOLAN BEES.

This race, from Carniola, Austria, is not generally used in Massachusetts. Many who were interested when it was first introduced into America tried it and since discarded it; but 34 persons, or 3 per cent, reported having it in 1906.

OTHER RACES.

Practically every other race of bees known in the United States is on trial in Massachusetts. Several mention the newly introduced Caucasians. The Punic, Cyprian, and Banat bees are also reported.

Considering the races by localities in the State, it is difficult to see that either the Italians or the Germans are more common to any one section than to another. Italian blood tends to predominate. Personal observation, however, shows that hybrids or the more purely German are found in the back country, where newer methods of bee keeping usually receive less attention; the pure Italians and more recently introduced races are found near the large communities.

Table VI.—*Prevalence of different races of bees.*

	Italian.	Hybrids.[a]	Black or German.	Carniolan.	Other races.
Number reporting	594	342	196	34	....
Percentage	50	30	16	3	1

[a] Hybrids are largely an admixture of Italian and German races.

HIVES.

In 1852 Langstroth patented his movable-frame hive, which marked the beginning of modern bee keeping. In the same year he moved from Philadelphia, Pa., to Greenfield, Mass. Bee keeping was then in a deplorable condition, as he remarked, most of the hives in use being those impractical devices classed under the names of "box hives," "patent hives," and the like. According to the writer's observations, these old-fashioned hives are fast being replaced by frame hives; colonies in box hives in the country are being exterminated by disease; they are also bought up for transferring and for use in cucumber greenhouses; at present, bee keepers seldom, if ever, start with anything but frame hives. Of those who reported the kind of hive which they use, 10 per cent have exclusively box hives and 8 per cent more acknowledge having a few. Moreover, there are a thousand persons who did not reply, and it is fair to presume that a considerable percentage of these have box hives. It will, consequently, not be exaggerating to estimate that 25 per cent, and possibly 30 per cent, of the bee keepers of Massachusetts still use these hives to some extent. Lamentable, too, is the fact that the apiaries in Berkshire County, against the New York State line, are perhaps in worse condition, so far as the box-hive problem is concerned, than other apiaries of the State, for figures show that one-third of the bee keepers of Berkshire County are using the old-fashioned hive. This circumstance is particularly unfortunate because the flora promises good honey production; and again because this is a border-line county, which may serve, with its high percentage of box hives in which diseases are controlled with difficulty, as a source of bee diseases in both States.

The condition on the whole is hopeful—90 per cent of those reporting have largely or exclusively frame hives, which shows a progressive tendency.

It is not, however, within the province of this paper to discuss the relative merits of the various frame hives which are in use. The several makes and patterns in principle are the same; they vary only in detail of construction and proportion. Climatic conditions, the methods of the bee keeper, whether for comb or extracted honey—in a word, the needs of the individual should govern his selection.

By far the most popular hive is the one generally used in the United States, perfected by Langstroth. In its simplicity and proportions it has proven satisfactory to the climate of Massachusetts. Two sizes, the 8 and the 10 frame hives, are popular. According to the statistics, the 8-frame hive is more common (340 bee keepers report having it) than the 10 frame (260 bee keepers). There is a rather strong tendency, judging from remarks in the reports, toward the 10-frame hive.

Another 10-frame hive, devised in Franklin County, has a shorter and deeper frame[a] than the standard, and is second in popularity. Its use is rather local, however, being confined largely to central and western Massachusetts, where 100 bee keepers report having it.

There is but one "closed-end frame" hive in use to any extent. Seventy-seven bee keepers are using it.

Besides these three types and the box hive, there are a great many homemade contrivances and a few patent hives with some merit.

WINTERING.

METHODS.

Bees are wintered in two ways. By far the most common and at the same time least laborious and less efficient in the latitude of Massachusetts is on the summer stands. The writer has seen bees go through a winter in Massachusetts unprotected, without bottom board and the corners of the hive rotted away. All manner of devices for protecting the bees on the summer stands are used. They are packed, put in winter cases, and wrapped in paper. But the safest method in a climate as famous for severe and variable weather as that of

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[a] The frame is 14 inches long and 10¾ inches deep, with a top bar one-half inch thick, 1 inch wide, and 16⅛ inches long, with the corners clipped at each end. The ends of the frames are one-half by seven-eighths inch, and the bottom bar is one-fourth by seven-eighths inch.

Massachusetts is to winter in the cellar. Unfortunately, many of those who attempt it are not altogether proficient. Of those who have reported their method of wintering only 13 per cent winter their bees in a cellar. It is well established that by proper cellar wintering the loss in northern countries may be reduced to a minimum. In order to do this properly the bee keeper must be painstaking and observing; he must use a dry cellar and maintain as nearly a uniform temperature as possible.

MORTALITY.

In New England and the Northern States loss during severe winters may run as high as 70 per cent. This loss is greatly reduced in favorable winters, when it is as low as 10 per cent. Were all the bee keepers competent and careful, this loss might generally be reduced to 2 or 3 per cent.

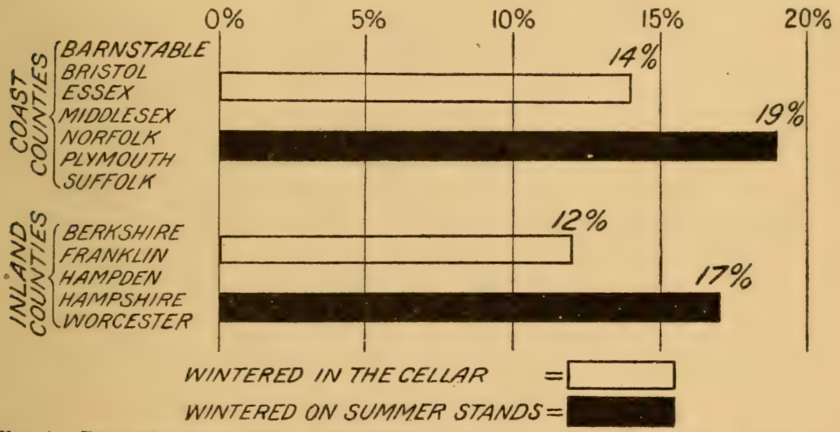

FIG. 1.—Proportionate loss of bees wintered in cellars and on summer stands. (Original.)

In the winter of 1906–7, which was not especially severe, the damage amounted to 16 or 17 per cent (see fig. 1); although this was not disastrous, it was too great a loss. It taxed the bee keepers of the State $4,886, valuing each colony at $3.50. With plenty of stores and proper protection it would not be expected that one-sixth of all the bees in the State, 1,396 colonies, should succumb during winter. The loss was most severe in localities where disease is now known to exist, which suggests that the excessive loss in a measure resulted from the depletion of colonies by disease.

BEES IN GREENHOUSES.

The use of bees in cucumber greenhouses is one of the many phases of bee keeping, perhaps the most prosperous or certainly that most peculiar to Massachusetts. The industry is little known outside of this State, yet growers in other Atlantic and Central States have undertaken it to some extent. Originating in Worcester County, it has assumed large proportions through the eastern part of Massachusetts. The accompanying map (fig. 2) shows the approximate location of the industry. It is a difficult task to obtain satisfactory data on this phase of apiculture. Market gardeners who grow cucumbers under glass do not consider themselves apiarists; on this ground they largely disregard requests for information. Only through a personal canvass among the growers has information been obtained.

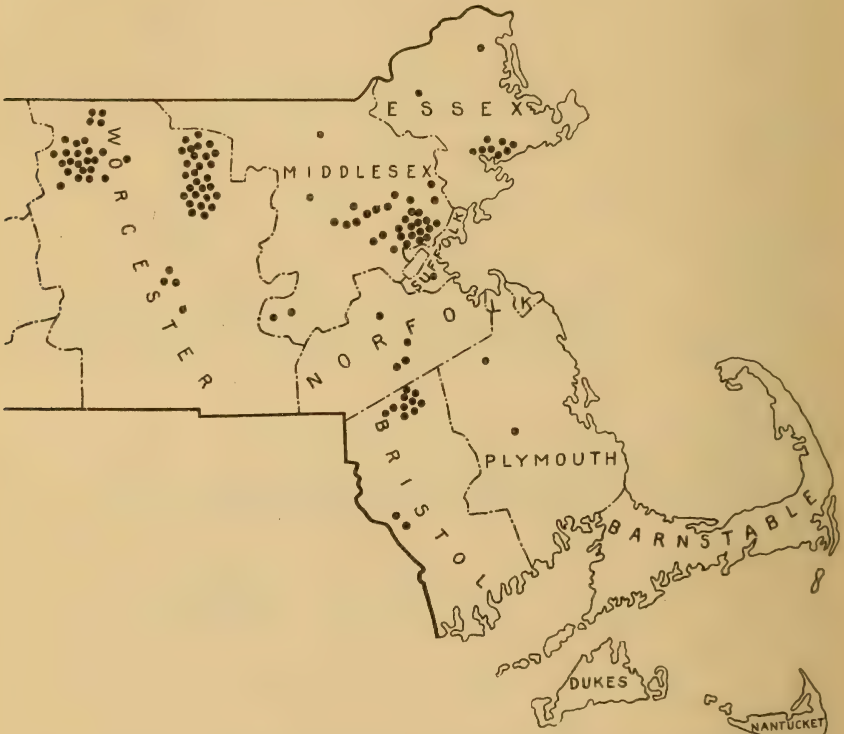

FIG. 2.—Approximate location of greenhouses in which bees are used for the pollination of cucumbers. (Original.)

There are at least 118 greenhouse cucumber growers. Only 73 of these, however, have furnished definite figures. These growers, including some of the largest and many of the smaller producers, use on an average 8 colonies of bees a year to set the crop. If the 118 known growers, which is not by any means the total number, require on the average 8 colonies each, nearly a thousand hives of bees would be utilized annually and, if the statistics from every grower were at hand, the writer feels sure several hundred colonies more than a thousand would be needed. When it is considered that practically all of these colonies are totally ruined while in the greenhouses and that the demand for bees is on the increase each year, it may be readily seen what excellent opportunity there is of producing bees for greenhouse use. Considering the recorded sale of bees in 1906, which amounted to 1,027 colonies, it is probable that these sales must have been largely a result of the demand for greenhouse use. In illustration of the extent to which bees are used for this purpose it may be mentioned that one grower who picks 10,000 bushels annually requires 80 colonies of bees; another having 40 acres under glass requires 35 to 40 colonies; a great many of the smaller growers use from 5 to 20 colonies. Cucumber growers, as a class, know little of bee-keeping methods, but they are anxious to learn. They feel that they must, in the stress of competition and high expenses, reduce the cost and loss in bees.

Bees are introduced into the greenhouses as soon as the cucumber vines begin to bloom. If the houses are large, two or more hives, according to the area of the house, are placed on boxes on the beds or hung in the gables of the house. Various other methods of introducing the hives are also employed. Not being able to secure sufficient stores in the winter, the colonies dwindle or become depleted in seven or eight weeks or less. It is a common practice among the growers to feed their bees sugar sirup or other sweets. Besides not being able to secure nectar to any extent from the cucumber blossoms, the bees are also unable to gather much pollen, which is probably a factor in the rapid depletion of the colonies. During the spring and summer, however, bees in the houses fare better, because they are able to escape, through ventilators and lights of glass removed for their exit, to the fields, where they secure nectar and pollen. Even under these circumstances the writer has seen colonies with no stores, with only a handful of bees and with scattered and half-starved brood. It is not surprising under such conditions that bee moths are such a great annoyance. To an experienced bee keeper the reason for their presence is obvious; when a colony becomes weakened the moth gains headway on the combs. No remedy for the moth in dwindled colonies can be suggested save killing the larvæ as they appear in the hive. A means of keeping the colonies strong must first be looked for, which will relieve the bee-moth nuisance. Without doubt, however, the pest could be reduced if the greenhouse men would be more careful in disposing of hives in which the bees have died. The moths breed by thousands in discarded hives, and later are at hand to infest fresh material. Under no circumstance should discarded combs be cast outside on the rubbish heap to be devoured by the bee moths. Such a practice is a menace to bee keepers for miles around.

TABLE VII.—*Distribution of greenhouse cucumber growers and record of bees used in greenhouses.*

County.	Number known to be engaged in cucumber growing.	Number reporting.	Number of colonies of bees known to be used annually.
Bristol	12	7	140
Essex	10	2	15
Middlesex	33	21	244
Norfolk	4	1	50
Plymouth	2	1	20
Suffolk	1	1	15
Worcester	56	40	100
Total	118	[a]73	[b]584

[a] Average of those reporting, 8.

[b] Estimated total, 944.

THE BEE MARKET.

It is doubtful whether in any other State in the Union more colonies of bees are sold, in proportion to the number on hand in the spring, than in Massachusetts. As is pointed out, the cucumber industry has much to do with this. Although there are many small, more or less amateur bee keepers in the State who customarily sell their surplus colonies, the trade is not at all confined to them. The supply houses and commercial bee keepers sell heavily, which is remarkable in a region where there is so little bee keeping on a large scale. Peculiarly, every county in the State shares in the trade about equally, in proportion to their respective number of colonies. The table, arranged from the statistics of 1906, shows that the bee keepers of Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, and Worcester counties sold approximately one-fifth of all the colonies on hand in the spring. Plymouth County, however, took the lead, selling 39 per cent, while in the remote counties of Barnstable and Berkshire, and in the metropolis county, Suffolk, the sale was relatively light.

TABLE VIII.—*Number of colonies sold as compared with colonies on hand in spring of 1906.*

County.	Number of colonies of bees.		County.	Number of colonies of bees.	
	Spring of 1906.	Sold in 1906.		Spring of 1906.	Sold in 1906.
Barnstable	185	1	Hampshire	408	46
Berkshire	495	29	Middlesex	962	142
Bristol	321	80	Norfolk	364	72
Essex	531	107	Plymouth	463	170
Franklin	491	102	Suffolk	57	3
Hampden	366	73	Worcester	1,199	202

PRICES OF BEES.

Figured on a basis of $5 a colony, which is an exceedingly low average price, the total sales reported for 1906 would have amounted to $5,135; at $6 per colony they would have amounted to $6,162, which more justly represents transactions. Colonies of bees sell as low as $2, or, if they are in a nail keg or soap box, for $2.50; at about $3 if in a regular box hive; and from $4 to $10, according to the race, strength, and season, if in frame hives of standard patterns; a usual price is $6. The customer sometimes furnishes an empty hive to the bee keeper, in which to hive a swarm. Such swarms bring about $3.

THE QUEEN TRADE.

Besides a trade in colonies of bees, there are several persons interested in commercial queen rearing. All but three of these, however, do a relatively local business. On account of late and cold springs, Massachusetts is handicapped in producing early queens for market which shall compete with those raised in the South. The prices prevailing throughout the country—75 cents, $1, and up—are charged for queens produced in Massachusetts. It is difficult to calculate just how many queens are reared for sale, but an estimate of 500 may not be far from correct.

ENEMIES.

The only enemy which is formidable in all parts of the State, but which is not detrimental to progressive bee men, is the bee moth, *Galleria mellonella* L. This insect, however, has been credited by all the early apiarists, Langstroth included, with devastating, crippling, and practically annihilating the bee-keeping interests throughout New England. According to Edmund Smith,[a] it first took hold in eastern Massachusetts about 1800. In 1805 it reached Connecticut. Thence it spread westward. Writers—as, for instance, Smith—were formerly inclined to consider the moth as a formidable enemy. Smith says: "For a time, wherever it appeared it nearly destroyed the bees. At first it was more fatal than it has been since." The inroads of the moth led to all sorts of claptrap devices in the form of "patent hives" to protect the bees from the pest. But there is serious doubt, in view of recent discoveries of the relation of moths and bee disease, if this historical disaster was really due to the moth. There is good reason to believe moths were secondary, while disease, not then understood, was primary. This matter is more fully discussed in a former paper.[a] The moth does not materially damage strong, healthy colonies, but is a menace only to persons who are inattentive to their bees or who are careless, leaving empty combs about their hives and bee yards, and who fail to recognize and to treat bee diseases. Combs not in use or not covered by bees should be fumigated with carbon bisulphid and sealed in tight boxes for storage.

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[a] Smith, Edmund, Chairman. 1864. Bee Culture, Essex. From the report of the Committee on Bread and Honey. Abstract of the returns of the agricultural societies of Massachusetts. Bound together with Eleventh Annual Report of Secretary of Massachusetts Board of Agriculture, pp. 221–229.

DAMAGE TO THE BEE-KEEPING INDUSTRY BY THE GIPSY MOTH (PORTHETRIA DISPAR) AND BROWN-TAIL MOTH (EUPROCTIS CHRYSORRHŒA).

Numerous complaints came from eastern Massachusetts, where gipsy and brown-tail moths are doing tremendous damage to forest and shade trees, that they were causing a loss to the apiarist as well. Damage is done both directly to the bees and indirectly to the honey flora.

From Cliftondale, Essex County, one bee keeper says that they have bothered during June and July by trying to crawl in at the entrance of his hives. Another speaks of the caterpillars having eaten up all the plants which the bees commonly forage upon, save golden-rod and burdock, and have thus caused a loss of his bees. Failure of his honey crop in 1906 is attributed to severe ravages of gipsy and brown-tail moths. The basswood of New England was formerly a good honey producer and could be counted upon for a crop, is a report from Melrose, but since the brown-tail and gipsy moths defoliated the trees it can no longer yield much. A Medford bee keeper contributes this interesting note:

> Gipsy and brown tails have so spoiled the fruit bloom, an important factor in spring building, that colonies fail to become sufficiently strong for the harvest. The willow, maple, and elm, early pollen yielders, have also suffered from the moths, which has consequently damaged bee keeping.

Another peculiar case is reported from Cliftondale. Brown-tail and gipsy moths were so thick on the trees when a number of swarms came out that the bees did not stay near the apiary.

> The trees were covered with them so that the bees would not stay to be hived. * * * In regard to the honey plants, the moths destroyed all the blossoms on the fruit trees and wild plants. Every place was covered with them each year from 1904 to 1906; the result is that there was no honey this year (1906), owing to so many of the fruit trees and honey plants being destroyed by the pest.

BEE DISEASES.

This subject has already been treated with some detail in a former paper.[b] Since the appearance of that paper, however, the extent of diseases and the damage they are doing have become more fully realized. Consequently their general distribution has been found to be even greater than was then believed.

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[a] Gates, Burton N. 1908. Bee Diseases in Massachusetts. Bul. No. 75. Part III, Bureau of Entomology; Bul. 124, Mass. Agr. Exp. Station.

[b] Ibid, pp. 23–32; also Bul. No. 124, Agr. Exp. Station, Amherst, Mass.

BEE KEEPERS' ORGANIZATIONS.

Bee keepers' societies, fairs, institutes, conventions, and the course of instruction in bee keeping at the Massachusetts Agricultural College at Amherst are strong factors in the advancement and progress of apiculture in Massachusetts. The societies bring together the practiced and proficient bee keepers in several sections of the State. The instruction at Amherst reaches a few, largely beginners, each year; conventions and institutes bring together the new and the old bee keepers from over a large area for consideration of present-day problems; the State and county fairs and agricultural shows educate the public and benefit the industry.

There are at present two societies organized in the interest of promoting bee keeping. The oldest is the Worcester County Bee Keepers' Society, organized April 14, 1900. Meetings are held monthly throughout the winter months. At least once each summer there is a field meeting and institute. Since 1906, in the fall of each year, a " bee show " or fair is held at Worcester, where are held competitive exhibits of bees, products, supplies, etc. There is usually a series of lectures in connection with the fair.

The other society is the Massachusetts Society of Bee Keepers, which was organized March 24, 1906, when the Massachusetts Apicultural Society was disbanded. Meetings are held in Boston once each month during the winter.

Another society, to be called the Franklin, Hampshire, and Hampden Bee Keepers' Association, was provisionally organized at an institute meeting of the Massachusetts State Board of Agriculture at Ludlow, Mass., July 21, 1908.

INSTRUCTION IN BEE KEEPING.

At the Massachusetts Agricultural College, Amherst, there is given each year, beginning the fourth Wednesday in May and continuing two weeks, a course in apiculture, which is free to those who enroll. The course includes excursions to apiaries of peculiar interest, lectures, and practical demonstration and practice.

CONVENTIONS.

The Massachusetts State Board of Agriculture is exceedingly interested in promoting bee keeping and holds several institutes each year, usually with the bee keepers' societies. Several papers on bee keeping, enumerated in the appended bibliography, have been published by the board.

SUMMARY.

As early as 1644 the colonies made a beginning in apiculture in Massachusetts. More than two centuries passed, however, before modern bee keeping began, which came with the invention of the frame hive by Langstroth in 1853. To-day there are more than 2,100 persons in the State who derive some profit from their bees. The bee keepers who reported in the spring count of 1906 had 5,839 colonies, or an average of 5.5 colonies. Massachusetts needs fewer but more proficient bee keepers, who will undertake their work along business lines. The major part of Massachusetts is quite as inviting and promising as Vermont and New York State, where bee keeping is more profitably conducted.

There are but three persons who report 75 to 100 colonies in their yards, and but two who have more than 100 colonies. The number of amateur bee keepers is reduced through the dropping out of 50 per cent of the beginners during the past five years.

In the production of honey and possibly of wax the effect of an excess of semiproficient bee keepers is again apparent. In 1906 the honey crop reported was 145,257 pounds, which is the largest recorded for the State. But this is small when it is remembered that in the West single individuals frequently produce in a single year from a quarter to a third more honey than Massachusetts' total annual harvest. The crop would have been materially heavier if those who reported had even approached the standard average of 35 pounds instead of having harvested only 24 pounds. This lowering of the average crop is in a large measure due to the great number of nonprogressive small bee keepers and to the presence of bee diseases.

The more important honey sources, as reported by the bee keepers in all parts of the State, are clovers, golden-rod and asters, fruit bloom, basswood, wild raspberry and blackberry, sumac, and locust. Some other plants, such as clethra and huckleberry, are of local importance and some listed as of minor importance are probably underestimated.

The Italian race in varying degrees of purity is most popular. The German or "black" still persists, but is rarely found pure.

Twenty-five per cent of the bee keepers still use box hives to some extent. The presence of box hives is most noticeable in the back country, where modern methods penetrate less rapidly. Of the frame hive types, the one standard for the country, the Langstroth, is most generally used.

The loss in the winter of 1906–7 was 16 to 17 per cent, which taxed the bee keepers nearly $5,000. By far the majority winter their bees on summer stands, protected in various ways or unprotected. A few take advantage of cellar wintering, but most of those who follow this practice are not especially proficient.

A thousand colonies or more are annually used in cucumber greenhouses. Since practically all of these colonies are useless after coming out of the houses, there is a constant demand and sale for bees. Several greenhouse men use from 40 to 80 colonies a year. The average number reported is 8 colonies. In the sale of bees the several counties, exclusive of Barnstable, Berkshire, and Suffolk, sold in 1906 approximately one-fifth of all their bees, spring count. In Plymouth County the sale amounted to 39 per cent. The total income amounted to between $5,000 and $6,000. The queen-rearing industry is limited to a few persons and late springs make it difficult to compete with southern producers.

The chief enemy reported is the bee moth. There is great doubt, however, if the damage attributed is really and primarily due to it. There is, on the other hand, sufficient reason to believe that disease is primary and that destruction by the moth is secondary. Gipsy and brown-tail moths are also reported as interfering severely with apiculture in the eastern part of the State.

Massachusetts is particularly fortunate and in some ways in advance of other communities in her bee keepers' institutions. Not alone do local societies aim to promote bee keeping, but the State Board of Agriculture, State Experiment Station, and Agricultural Station as well, are deeply interested in the advancement of apiculture.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 75.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS ON APICULTURE.

CONTENTS AND INDEX.

ISSUED JANUARY 27, 1911.

216062

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

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I. PRODUCTION AND CARE OF EXTRACTED HONEY.

By E. F. PHILLIPS, PH. D., *In Charge of Apiculture.*

METHODS OF HONEY TESTING FOR BEE KEEPERS.

By C. A. BROWNE, PH. D., *Chief, Sugar Laboratory, Bureau of Chemistry.*

II. WAX MOTHS AND AMERICAN FOUL BROOD.

By E. F. PHILLIPS, PH. D., *In Charge of Apiculture.*

III. BEE DISEASES IN MASSACHUSETTS.

By BURTON N. GATES, *Expert in Apiculture.*

IV. THE RELATION OF THE ETIOLOGY (CAUSE) OF BEE DISEASES TO THE TREATMENT.

By G. F. WHITE, PH. D., *Expert in Bacteriology.*

V. A BRIEF SURVEY OF HAWAIIAN BEE KEEPING.

By E. F. PHILLIPS, PH. D., *In Charge of Apiculture.*

VI. THE STATUS OF APICULTURE IN THE UNITED STATES.

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E. F. Phillips, *in charge.*

G. F. White, *expert in bacteriology.*
B. N. Gates,[a] A. H. McCray, *apicultural assistants.*
J. A. Nelson, R. E. Snodgrass,[a] *agents and experts.*
Ellen M. Dashiell, *entomological preparator.*
T. B. Symons, College Park, Md., *collaborator for Maryland.*
H. A. Surface, Harrisburg, Pa., *collaborator for Pennsylvania.*

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[a] Resigned.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., December 3, 1910.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 75, seven papers dealing with bee culture. These papers, which were issued separately during the years 1907, 1908, and 1909, are as follows: Production and Care of Extracted Honey, by E. F. Phillips, and Methods of Honey Testing for Bee Keepers, by C. A. Browne; Wax Moths and American Foul Brood, by E. F. Phillips; Bee Diseases in Massachusetts, by Burton N. Gates; The Relation of the Etiology (Cause) of Bee Diseases to the Treatment, by G. F. White; A Brief Survey of Hawaiian Bee Keeping, by E. F. Phillips; The Status of Apiculture in the United States, by E. F. Phillips; Bee Keeping in Massachusetts, by Burton N. Gates.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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[a] The eight papers constituting this bulletin were issued, two on December 19, and one each on December 31, 1907, June 30 and December 26, 1908; January 19, January 25, and May 24, 1909, respectively.

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ERRATA.

Page 49, line 14, for *civcutarium* read *cicutarium.*
Page 49, line 24, for *Lupins* read *Lupin.*
Page 49, line 24, for *plants* read *plant.*
Page 49, line 18 from bottom, for *Thevitia* read *Thevetia.*
Page 49, line 18 from bottom, for *nereifolia* read *neriifolia.*
Page 49, line 17 from bottom, for *supp.* read *spp.*
Page 49, line 15 from bottom, for *Artemesia* read *Artemisia.*

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